National Initiative on Climate Resilient Agriculture

Real Time Contingency Planning
under Major Rainfed Production Systems in India

Annual Report
2011-12

NICRA - AICRPDA

हर कदम, हर डगर
किसानों का हमसफर
भारतीय कृषि अनुसंधान परिषद

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NICRA

All India Coordinated Research Project for Dryland Agriculture
Central Research Institute for Dryland Agriculture
Hyderabad - 500 059

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Front Cover

Clockwise : (1) Conservation furrow in Fingermillet + Pigeonpea system (8:2), Bangalore; (2) Early sown Pearlmillet in Pearlmillet + Pigeonpea intercropping (5:1), Anantapur; (3) Ridge and furrow in Soyabean + Pigeonpea intercropping (4:2), Parbhani; (4) Groundnut + Sesame intercropping (6:2), Arjia.

Back Cover

Dr.S. Ayyappan, Secretary, DARE & DG, ICAR, releasing the Technical Bulletin on Awareness on Climate Change during Review Meeting of AICRPDA, NASC, New Delhi, 7th April, 2011.

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Preface

It is now evident that climate change and its consequences are beginning to impact agriculture and allied sectors in India. In agriculture, rainfed agriculture is more vulnerable to climate change and variability. To make the Indian agriculture more climate resilient, there is an urgent need to demonstrate and disseminate already available best bet practices on farmers' fields in specially vulnerable regions, in addition to long term strategies research. In this context, there is a need to evolve innovative institutional mechanisms, like Village Level Climate Risk Management Committee, Custom Hiring Centers, etc. for successful adoption, ownership and upscaling of proven practices.

Since 2010-11, the technology demonstration component of National Initiative on Climate Resilient Agriculture (NICRA) is being implemented across 23 network centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA), both on-station and on-farm, under 4 Sub-projects, viz., (i) Real time contingency plan implementation in a participatory mode, (ii) Rainwater harvesting *(in-situ and ex-situ)* and efficient use, (iii) Efficient energy use and management, and (iv) Alternate land use. The focus was on participatory demonstration of location specific climate resilient agricultural technologies / package of practices developed by 23 AICRPDA Network Centers (including voluntary Center, IGFRI, Jhansi). The on-farm program is being operational in 15,793.75 ha in 36 adopted villages in 26 districts and 15 States in the country.

I compliment Dr.GR. Maruthi Sankar, Incharge Project Coordinator (Dryland Research), Dr.G. Ravindrana Chary, Principal Scientist (Agronomy), Er.R.Nagarjuna Kumar, Scientist (Computer App) and Dr.PK. Mishra, former Project Coordinator (Dryland Research) for their efforts in program development, implementation and monitoring. The contribution of scientists and staff of AICRPDA and ORP centers for successfully undertaking the program in target areas is acknowledged. This report presents the details on demonstration of real time contingency planning of both on-station and on-farm along with the achievements in other thematic areas by AICRPDA Network Centers. I thank Dr.S. Ayyappan, Director General, ICAR, Dr.AK. Sikka, DDG (NRM), Dr.AK. Singh, former DDG (NRM), Dr.B. Mohan Kumar, ADG (Agron & AF) for providing guidance and support to AICRPDA from time to time.

B. Venkateswarlu

(B. VENKATESWARLU)
Director

28th May 2013

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Executive Summary

The National Initiative on Climate Resilient Agriculture (NICRA) Program at 23 Centers of All India Coordinated Research Project for Dryland Agriculture (AICRPDA) was initiated in 2010-11. The representatives of villages were selected based on climate vulnerability by each center. The PRA and focused group discussions (FGDs) were conducted to assess the natural resources, socio-economic status, institutional arrangements, farming systems and constraint analysis in the NICRA villages to sensitize the farmers about climate veracity/change and its impact on rainfed agriculture etc, to identify traditional coping mechanisms, to identify interventions for demonstration of proven rainfed technologies for weather aberrations and or to develop realtime contingency planning . The Technology Demonstration component of NICRA, both on-farm and on-station, was operationalized during 2011-12 focusing on four theme areas viz. i) Real Time Contingency Crop Plan Implementation in a participatory mode, ii) Rainwater harvesting (*in situ* and ex situ) and efficient use, iii) Efficient energy use and management, and iv) Alternate land use for carbon sequestration and eco-system services. During 2011-12, the demonstrations with improved package of proven rainfed technologies covered a total area of 19.80 ha in 3495 farmers' fields in 40 villages in 26 districts located in 15 States. The salient achievements under technology demonstration (both on-station and on-farm), strategic research and other activities under NICRA at AICRPDA centres are summarized below.

Technology Demonstrations (*both On-Station and On-Farm)*

i) Rainwater Management

Under this component, the major thrust was on *in situ* moisture conservation through land configuration/inter-terrace land management practices suitable to the soil types and rainfall situations while under *ex situ* rainwater management, the focus was on rainwater harvesting and storing in farm ponds for efficient utilization either as supplemental/life saving irrigations to *kharif* crops or presowing or supplemental irrigations to *rabi* crops. Both *in situ* and *ex situ* rainwater management not only mitigated dry spells but increased crop yields, RWUE and economics (net returns and BC ratio).These interventions were: at Biswanath Chariali, compartmental bunding for *Sali* rice yield in real time contingency; at Chianki, ridge and furrow system in maize with 47.9% compared to flat bed system; at Bangalore, conservation furrow between pigeonpea rows in fingermillet + pigeonpea (8:2) system in groundnut + pigeonpea (8:2) system with RWUE 6.2 kg/ha/mm compared to no conservation furrow (3.97kg/ha/mm); at Varanasi, land configuration with ridge and furrow operated planting provided improved drainage (during excess rainfall events resulting in better rice (furrow) + pigeonpea (ridge) intercropping system; at Solapur, ridge furrow system and compartmental bunding enhanced crop yield by 15% in sorghum and 52 % in pigeonpea; at Kovipatti, BBF technique along with the tractor drawn ferti-cum-seed drill increased yields maize, cotton, greengram and blackgram compared to farmers practice resulted in yield increase up to 9 % and RWUE upto 10.05 kg/ha/mm; at Bijapur, under midseason drought, compartmental bunding enhanced *in situ* moisture conservation and mitigated drought spells during vegetative and flowering stages of chickpea with yield increase by 63 % and by RWUE 63% compared to no compartment bunding; at Akola, opening furrow at 30 DAS in cotton enhanced yield by 5.22 % and RWUE by 4.84%; at Parbhani, under deficit rainfall (198 mm) compared to normal (830 mm), opening of conservation furrow at 30 DAS in sole soybean increased yield by 26.6% with RWUE of 2.98 % at Rajkot, under delayed onset of monsoon and mid season drought situation, ridge and furrow system in groundnut during critical stage of groundnut and blackgram increase d crop yield by 3.7 and 11 % respectively and at Agra, ridge sowing, compartmental bunding, deep ploughing in summer and tillage after each effective rainfall enhanced yield of pearlmillet upto 50% and mustard upto 44 % as compared to farmers' practice and sowing of pearlmllet on shoulder of ridge with ridger seeder r gave 41 % higher yield compared to broadcasting method (2.71 kg/ha) and at Anantapur, in castor, conservation furrow enhanced *in situ* moisture conservation resulted in overcoming dry spells during September and increased rain water use efficiency (1.7 kg/ha/mm); at Arjia, ridge furrow system and

peripheral bunding mitigated dry spell ad resulted in maize yield by 21.1%, RWUE by 19.6% compared to flat bed system.

Under extreme weather events like unusual high intense rainfall events in short span at Varanasi these events were better utilized for harvesting runoff in farm ponds and supplemental irrigation to *rabi* crops, viz., wheat, chickpea and mustard resulting in irrigation system. At Bangalore , the stored water in farm ponds was utilized supplemental irrigation to establish horticultural plants to grow vegetable and fruits around the farm pond and rearing fish. This resulted in higher income and RWUE and similarly at Solapur, the harvested water was utilized for establishment of plants in agrihortisystems; at Indore, for pre-sowing irrigation of wheat and chickpea resulted in increase yield by 62 % and 44.4 % compared to no pre-sowing irrigation; at Anantapur, efficiently utilized for supplemental irrigation (10 mm) during seed and pod development of castor and groundnut respectively resulting in increase by 20 % and 46 % in castor and groundnut respectively; at Jagdalpur, supplemental irrigation (10-14 cm) with harvested rain water in farm ponds in vegetable crops gave higher income and BCR upto 8.58 and at S.K.Nagar, the supplemental irrigation from the harvesting from farm pond through castor and cumin increased the yield upto 40.7 % and 43.2 %; at Arjia, supplemental irrigation to vegetables viz. kachari during kharif and to coriander-green, gave higher water productivity of 6.46 and 1.58 kg /sq.m., further, the yield increase was up to 51.1% in maize + blackgram and groundnut + sesame intercropping systems utilizing supplemental irrigation from the stored water in renovated *nadis*,

ii) Realtime Contingency Planning

Under real time contingency planning, based on early, midseason or terminal drought situations the coping strategies adopted/demonstrated included were crop/soil/moisture management practices (change in crop/variety (early, medium and late maturing),crop diversification, practices like change in seed rate, gap filling, thinning, life saving/supplemental irrigation nutrient management, interculture and weed management practices etc).

At Bangalore, a dryland Agri-tech park was established in 3 ha area with the demonstration of improved rainfed technologies, viz., improved varieties, real time contingency planning etc. During 2nd fortnight of June and 2nd fortnight of August. In Real time Contingency Planning , short, medium and long duration variety fingermillet were demonstrated. Further, contingency measures were adopted in various crops under delayed onset of monsoon. Transplanting on long duration fingermillet (MR-1) gave higher yield (2623 kg/ha) and RWUE (8.01 kg/ha/mm compared to direct sown fingermillet (MR-1 with grain yield of 2172 kg/ha and RWUE of 5.56 kg/ha/mm; at Biswanath Chariali, introduction of short and medium duration cultivars of *Sali* rice varieties (Basundhar) performed better during mid season drought and crop diversification from *Sali* rice to vegetables using harvested rain water in farm pond gave higher income with vegetables like potato and rape seed; at Chianki, improved cultivars of rainfed upland rice, viz., RR-616-B-2-75-2m Vandana BVD-108, etc., were involved in delayed onset of monsoon of which performed better with 2600 kg/ha. Maize hybrid variety Kanchan performed better under deficit rainfall situation while Asha variety of pigeonpea cultivar (1680 and Shekhar variety of sesame (459 kg/ha performed better under delayed med season drought situation; during *rabi*, Chickpea, cv. KPG-59 (834 kg/ha, lentil cv. PL-639, mustard cv. Pusa Gold (695 kg/ha) performed better under mid season drought situation. Pigeonpea-Okra (3132 kg/ha) found to be better under delayed onset of monsoon in mid season drought situation; at Faizabad, under normal onset of monsoon, upland rice cv. NDR-97 (2015 kg/ha), pigeonpea (NDA-2) of 1695 kg/ha gave better yields compared to local variety ; at Phulbani under delayed onset of monsoon, contingent crops like radish, cowpea, pea, greengram, blackgram, and horsegram performed better under early onset of monsoon, rice under early and mid season drought situation Khandgiri (2338 kg/ha) and maize + cowpea (2:2) intercropping system performed better; at Hisar, under delayed onset of monsoon and mid season drought, introduction of improved varieties of rainfed crops are greengram (Muskan), clusterbean (HG-365) cowpea (235) and mustard (RH-30) performed increasing the yield of crops upto 45.3%; at S.K.Nagar, under early season drought, introduction of improved varieties/hybrids of pearlmillet, castor, greengram, clusterbean, mothbean and in castor + greengram enhanced the yield with RWUE upto 1.33 kg/ha/mm and BC ratio upto 7.42 and under delayed onset of monsoon , introduction of improved varieties of pearlmillet, clusterbean, castor, maize,

greengram and blackgram resulting in yield increase upto 153.5; at Bijapur, improved varieties of chickpea (JG-11) performed better with increase in yield by 21% compared to local variety (305 kg/ha; at Akola, under midseason drought situation, introduction of improved variety of sorghum (CSH-14) and cotton + greengram (1:1), greengram + pigoenpea (4:2) and soybean + pigeonpea (4:2) systems with suitable varieties, viz., JS-335 (soybean, PKV-Tara (pigeonpea), Greengold (greengram) enhanced the yield upto 38% with BC ratio of 2.45; at Parbhani, under normal onset of monsoon and mid season drought situation, improved varieties of soybean (MAUS-71, MAUS-81), pigeonpea (BSMR-736, BDN-708 and BSMR-853), greengram (BM 2002-1), blackgram (BDU-1 and pearlmillet (ABPC-1 performed better resulted in yield increase upto 28.6; at Kovilpatti,under excess rainfall situation during August, September, October and November and also mid-season drought during June, July and dry spells during June, July and December, the improved varieties of cotton (RCH-530), maize (900 M Gold), Greengram (CO-6), blackgram (normal), pearlmillet (80 M 32) and sunflower (CO-SFV)-5 performed better resulted in higher yield and higher RWUE upto 13.49 kg/ha/mm (900 M Gold); at Parbhani, **u**nder delayed onset of monsoon and mid season drought (August, September, November and December), introduction of improved cultivars of maize, greengram, sunflower, safflower, cotton, sorghum, soybean and pigeonpea resulted in higher yield; at Solapur, introduction of improved varieties pigoenpea (Vipula) and sunflower (Bhanu) during kharif performed better during dry spells in October and yield increase was 54% in pigeonpea and 14% in sunflower compared to local cultivars; at Indore, under aberrant monsoon situation, foliar spray of VAM-C 50% SL @ 3.75 lha^{-1} on soybean, maize and horsegram recorded 17.5, 27.0, 35.9 and 42.3 % higher seed yield respectively than control (no spray of chemical); under no rainfall situation during *rabi*, introduction of improved varieties of chickpea (JG-412) and wheat (GW-366) performed better with yield increase upto 44.2%; at Anantapur, the wet spells, during *kharif* , during flowering and pegging stage had drastic effect on groundnut pod yield. However, K-6 and Narayani recorded higher pod yield during wet spells than TMV-2 and introduction of pearlmillet + pigeonpea (5:1) intercropping system as alternate strategy, the early sown pearlmillet (2^{nd} week of June) gave higher seed yield (750 kg/ha) while normal sown was failed (last week of July) due to moisture stress at knee high stage; at Rajkot, the cotton in both the normal and delayed onset of monsoon, sole castor recorded higher net returns 54314 and 54647/ha ; at Jhansi , the improved varieties of crops, viz., groundnut, blackgram, sesame performed better compared to local cultivars though there was intense rainfall events during 25^{th} SMW (207.4 mm) and 26^{th} SMW (223 mm); at Arjia, under early onset of monsoon, sole groundnut gave maize equivalent yield of 4774 kg/ha. Under late sown situation, groundnut sole and groundnut+ sesame gave maize equivalent yields of 4264 kg/ha and 4023 compared to sole maize (3623 kg/ha); at Arjia, Under midseason drought situation, improved varieties of maize, sorghum, blackgram and groundnut gave an increased yield up to 96.1% compared to local varieties; at Ballowal Saunkhri, introduction of improved varieties of rabi crops viz. wheat (PBW 175), taramira (TMLC 2) and raya (RLM619) under delayed sowing due to initial dry spell resulted in yield increase up to 68.5% over local cultivars and crop diversification with vegetable cultivation in NICRA villages gave higher net returns with BC ratio upto 8..33 in ash gourd and at Rakh Dhiansar, despite four excessive rainfall events during July (103.7 mm) and August (103 mm, 108 mm, 96 mm), improved hybrids (K-99,K-9451,K-517, Shaktiman) of maize performed better with yield increase upto 22.7% and RWUE up to 2.15 compared to local cultivars and during rabi, there was dry spell during 16^{th} September 2011 to 7^{th} January 2012 in the NICRA village. Due to introduction of improved varieties of chickpea (GNG-469), mustard (RSPR-01) and wheat (PBW-175), there was an yield increase up to 28 %.

iii) Energy Management

A Custom Hiring Centre (CHC) was established in each NICRA village with need based implements (both bullock drawn and tractor drawn) made available which ensured timely and precision in agricultural operations covering large areas in short span. Energy input and output for different crops and cropping systems was influenced by using yield with lower costs operations, further CHCs significantly contributed to alleviate labour shortage during peak demand period. At Biswanath Chariali, thresher, reaper, sprayers, etc., gave higher energy output and income with BC ratio of upto 2.2 in rice;; at Jagadalpur, Mahakal Seed drill gave higher energy efficiency, net returns compared to Bhoram Dev. Seed Drill or automatic

seed drill in fingermillet; at Hisar, during long dry spells, weeding and moisture conservation with weed hand hoe increased yield of pearlmillet, cowpea and mustard up to 20% compared to using Kasola; at Anantapur, sowing of groundnut with tractor drawn Ananta Planter gave higher energy output (2690 kg/ha) and net returns of Rs. 9817/ ha than the farmers practice (2690; Rs. 6232/ha); at Rajkot, introduction of rotavator in NICRA village, for *in situ* composting of cotton stalks in groundnut resulted in higher energy output and higher groundnut yield (1735) with net returns of 43294/ha and at Akola, demonstrated the efficiency of the PTO operated multipurpose thresher for soybean threshing; at Bijapur, 75 ha of compartment bunding could be done in the NICRA village with the availability of bund formers; at Solapur , sowing of *rabi* sorghum with tractor drawn 9-row CRIDA Planter and sowing of chickpea with bullock drawn CRIDA planter resulted in higher yield of 820 kg/ha in *rabi* sorghum and 1400 kg/ha of chickpea with field efficiency of 64.3% and 69.6 % of the implements respectively and at Rakh Dhiansar, sowing of maize with the liner, though consumed maximum energy, but gave higher maize grain yield (1540 kg/ha) compared to broadcasting (1050 kg/ha) and maize planter (1505 kg/ha).

iv) Alternate Land Use for Carbon Sequestration and Ecosystem Services

Agroforestry, agrohorti and other alternate land use systems help in both adaptation and mitigation. Hence, these interventions were made, both on-station and on-farm, to educate the farmers that climate change need to be tackled both short term and long term strategies. These interventions gradually attracting farmer's attention in the NICRA villages for adoption of these interventions to cope with climate variability in the region. At Varanasi, in custard apple and guava based agri-horti system, greengram found to be best intercropping with on-farm. ; at Bangalore, in mango based agri-horti-system, pigeonpea and fieldbean system intercrops of the pigeonpea and fieldbean were demonstrated; at Bijapur, Sapota, Simaruba, Aonla and Tamarind based agri-horti-systems in medium deep black soils with intercrops like chickpea, safflower were introduced. Chickpea, fig, drumstick of which Simaruba + guava + chickpea gave higher gross returns (77308/ha); at Akola, Custard and Hanuman phal based agri-horti-systems were established for demonstration. Custard apple + soybean gave RWUE of 32.33 kg/ha/mm while higher BC ratio (1.8) recorded with custard apple + greengram and pigeonpea system and at Arjia, on-farm demonstration of ber based hortipasture system with trench system of planting and improved grasses on nonarable land enhanced in situ moisture conservation and gave a grass yield *(Cenchrus setigerus)* of 8000 kg/ha as compared to local grass (4600 kg/ha);

NICRA-Strategic Research

- The climate vulnerability assessment at microlevel in three watersheds with diverse agroecological settings viz., Warkhed watershed , Akola district, Maharashtra, Sol ka Kheda watershed ,Bhilwara district, Rajasthan and Kavalgi watershed, Bijapur district, Karnataka indicated climate variability (rainfall) in respect of onset of southwest monsoon, sowing windows of major rainfed crops, shifts in cropping patterns, change in crop management practices etc.

The traditional coping strategies include:

- At Warkhed watershed, due to early season drought resowing of soybean and cotton and for excess rainfall situation gap filling and draining excess water in sorghum, soybean and cotton, stone plugging; while under terminal drought situation advance harvest in soybean and delay harvest in cotton and excess rainfall situation - delay harvest in soybean and cotton.

- At Kavalagi watershed: dry spells before sowing of rabi crops, fodder crops are preferred instead of chickpea and sorghum, change in variety of sorghum, chickpea, pigeonpea and wheat and if excess rainfall situation - change in crop instead of chickpea, sorghum ; dry spells at early crop stage -opening of conservation furrow in chickpea, resowing and gap filling in pigeonpea; and under terminal drought situation - delay harvest of chickpea and pigeonpea and insecticide spray in chickpea and sorghum.

- At Sola ka Kheda watershed: if dry spells before sowing of major crops like maize and groundnut-change in variety and under excess rainfall situation : cotton – change in crop; groundnut, maize, sesame; wheat – change in crop and or variety; dry spell at early crop stage - cotton – thinning; groundnut and maize – conservation furrow, thinning and gap filling and under terminal drought: delay harvest of cotton, groundnut, maize, sesame.

- There was marked change in soil properties in 2011 compared to 2001, particularly in respect of pH, organic carbon and available N, P and K across Entisols, Inceptisols and Vertisols in Warkhed watershed.At Warkhed watershed, across fallow lands, sorghum, soybean and cottons and across shallow entisols, deep inceptisols and very deep vertisols the SMBC ranged from 85.6 ug/g to 330.7 ug/g and DHA values ranged from 1.7 mic.g/g/hr to 8.4 mic.g/g/hr.

Launching Workshops in Adopted Villages:

The NICRA programme was launched in the adopted villages during March to November, 2011 and the PRA and FGDs were conducted for resource and socioeconomic inventory and constraints analysis.

Village Climate Risk Management Committees:

The Village Climate Risk Management Committees (VCRMCs) were formed to identify and facilitate implementation of interventions and smooth functioning of the programme. In all the adopted villages,

Custom Hiring Centres (CHCs) :

The CHCs were established wherein the need based improved implements (tractor drawn and or bullock drawn) were kept for hiring for timely agricultural operations with efficient energy use. A Custom Hiring Management Committee (CHMC) was also constituted in each village for time to decisions on hiring and maintenance of implements.

Review Workshops, Training/Meetings/Field days :

During the period, the programme was reviewed at highest level in ICAR. Regular farmer-scientists-stakeholder meetings were organized to sensitize the farmers about climate variability and its impact on agriculture and allied sectors and review the progress. Filed Days were also organized for sharing of experiences.

HRD :

Two trainings on Database Analysis and Management in Climate Variability and Rainfed Agriculture were organized by PC Unit, AICRPDA, Hyderabad for the scientist and technical staff of the AICRPDA Centers. At the centers also, trainings were organized for primary and secondary stakeholders on various aspects of improved dryland technologies.

Agroadvisories, Soil Health Cards and Community seed banks :

At some centres, agroadvisories were given in NICRA villages in collaboration with AICRPAM centres and IMD while real time contingency measures were advised for implementation in all the villages. Soil health cards were given to all the farmers in some NICRA villages while in progress at other centres. Community seed banks to meet the seed demand during contingency was NICRA villages adopted by Arjia centre.

Publications :

Few research papers, leaflets, popular articles etc. were published during the period.

Linkages :

For effective implementation of the NICRA programme, capacity building of the stakeholders etc, the centres established linkages with state line departments, KVKs, ATMA,NGOs,ICAR Institutes, various sate/central govt. schemes/programmes.

Visitors :

The on-station and on-farm demonstrations were visited by distinguished visitors at various centres.

Introduction

Climate change impacts on agriculture are being witnessed all over the world, but countries like India are more vulnerable in view of large population depending on agriculture, excessive pressure on natural resources and poor coping mechanism. Several models predict that rising temperatures, increased climatic variability and extreme weather events could significantly impact food production in coming years. Climate change projections made up to 2100 for India indicate an overall increase in temperature by 2- 4°C with no substantial change in precipitation. However, different regions are expected to experience differential change in the amount of rainfall in the coming decade (Kavikumar 2010). Besides, changed rainfall patterns, it is predicted that extreme events are likely to increase in the country resulting in more droughts and floods. Rainfed agriculture is considered to be relatively vulnerable to climate variability and change in view of its dependence on only rainfall. People dependent on rainfed agriculture are also less endowed in terms of financial, physical, human and social capital limiting their capacity to adapt to the changing climate. Climate variability is already impacting Indian agriculture. Heat wave during February- March in North India caused an estimated loss of 6 million tonnes of wheat in 2002-03. A decline in production of 60% in rapeseed and 50% in linseed was observed in Himachal Pradesh due to heat wave in March 2004. Pigeonpea crop in area of 7000 ha was damaged in Madhya Pradesh due to frost and cold (Venkateswarlu *et al,* 2011). Similarly, delayed onset of monsoon, mid season and terminal droughts in rainfed areas are causing huge losses to agriculture and livestock production.

Climate change/variability is not only affecting the livelihood of farmers but causing a decline in agricultural Gross Domestic Product (GDP). Within a span of one year, the country is experiencing severe droughts and floods in the same region posing serious problems to the farmers, agricultural scientists and extension staff. Fall in the yield of staples and consequent shortage of food grain lead to price rise and inflation affecting the poor most. To make the Indian agriculture more climate resilient, besides undertaking research to develop location specific climate resilient agricultural technologies, there is a need to make immediate efforts to transfer the already available agricultural technologies to the farmers' fields especially in more vulnerable regions. At the same time, there is also need to put in place innovative institutional mechanisms at the field level for successful technology adoption and up scaling. In order to deal with climate change in the right earnest, it has been planned to conduct extensive farmer participatory demonstrations of location specific climate resilient agricultural technologies/ package of practices developed by 23 centers of All India Co-ordinated Research Project for Dryland Agriculture (AICRPDA) under on-station and on-farm conditions under the National Initiative on Climate Resilient Agriculture (NICRA).

AICRPDA At a Glance : The All India Coordinated Research Project for Dryland Agriculture (AICRPDA) was launched in 1970 by the Indian Council of Agricultural Research in IV Plan period, in collaboration with the Government of Canada through Canadian International Development Agency (CIDA) with Co-coordinating Cell at Hyderabad, Andhra Pradesh. In 1985, the Project Directorate of AICRPDA was upgraded to the status of an institute i.e. Central Research Institute for Dryland Agriculture (CRIDA) to carry out basic and strategic research while network research under AICRPDA umbrella continued in applied and adaptive research mode.Presently, AICRPDA network has 22 centers and 8 Operational Research Projects (Fig. 1.) viz. 20 centers in State Agricultural Universities, 2 in technical/ other Universities and 3 in ICAR institutes located in 15 states in various agroecological settings (Table 1.) The project has several unique features compared to any other AICRP. At each center, location specific research based on natural resource management and socioeconomic status was the hallmark of the programme. Integrated Dryland Development Pilot Projects were started simultaneously and linked with this research network. Introduction of collaborative on-farm participatory research efforts in the Operational Research Project concept goes to the credit of the project. The domain of some centers also includes the tribal dominated districts.The project is supported by 516 staff memebres (126 scientists and 388 technical,

Table 1 : Agroecological setting of AICRPDA Network centers

Name of the Centre	SAU / ICAR Institute / Others Hqrs)	Agro-Climatic Zone (NARP) /Agro – ecosub region (AESR)	Climate**	Mean Annual Rainfall (mm)	Dominant Soil Type	Major Rainfed Production System
Agra (SC)	RBSC, Agra	South – western semiarid zone in Uttar Pradesh (4.1)	Semiarid (Hot dry)	665	Inceptisols	Pearlmillet
Akola (MC)	PDKV, Akola	Western Vidarbha Zone in Maharashtra (6.3)	Semiarid (Hot moist)	824	Vertisols	Cotton
Anantapur (MC & ORP)	ANGRAU, Hyderabad	Scarce rainfall zone (Rayalaseema) in Andhra Pradesh (3.0)	Arid (Hot)	544	Alfisols	Groundnut
Arjia (MC & ORP)	MPUAT, Udaipur	Southern zone in Rajasthan (4.2)	Semiarid (Hot dry)	656	Vertisols	Maize
Ballowal Saunkhri (MC & ORP)	PAU, Ludhiana	Kandi region in Punjab (9.1)	Subhumid (Hot dry)	1011	Inceptisols	Maize
Bengaluru (MC & ORP)	UAS_B, Bangalore	Central, eastern and southern dry zone in Karnataka (8.2)	Semiarid (Hot moist)	926	Alfisols	Fingermillet
Bellary (VC)	CSWCRTI, Dehradun	Northern dry zone in Karnataka (3.0)	Arid (Hot)	502	Vertisols	*Rabi* Sorghum
Bijapur (MC)	UAS_D, Dharwad	Northern dry zone in Karnataka (6.1)	Semiarid (Hot dry)	595	Vertisols	*Rabi* Sorghum
Biswanath Chariyali (MC)	AAU, Jorhat	Northwest Palin zone in Assam (15.4)	Perhumid (Hot)	1846	Oxisols	Rice
Chianki (MC & ORP)	BAU, Ranchi	Western plateau zone of Jharkhand (4.1)	Semiarid (Hot dry)	1149	Inceptisols	Rice
Faizabad (SC)	NDUAT, Faizabad	Eastern plain zone in Uttar Pradesh (9.2)	Subhumid (Hot dry)	1051	Inceptisols	Rice
Hisar (MC & ORP)	CCSHAU, Hisar	South-western dry zone in Haryana (2.3)	Arid (Hyper)	412	Inceptisols	Pearlmillet
Indore (MC & ORP)	RVSKVV, Gwalior	Malwa plateau in Madhya Pradesh (5.2)	Semiarid (Hot moist)	958	Vertisols	Soybean
Jagadalpur (MC)	IGAU, Raipur	Basthar Plateau zone in Chattisgarh (12.1)	Subhumid (Hot moist)	1297	Inceptisols	Rice
Jhansi (VC)	IGFRI, Jhansi	Bundhelkhand zone in Uttar Pradesh (4.4)	Semiarid (Hot moist)	870	Inceptisols	*kharif* Sorghum
Jodhpur (VC)	CAZRI, Jodhpur	Arid Western zone of Rajasthan (2.1)	Arid (Hyper)	331	Aridisols	Pearlmillet
Kovilpatti (MC)	TNAU, Coimbatore	Southern zone of Tamil Nadu (8.1)	Semiarid (Hot dry)	723	Vertisols	Cotton
Parbhani (MC)	MAU, Parbhani	Central Maharastra Plateau Zone in Maharashtra (6.2)	Semiarid (Hot moist)	901	Vertisols	Cotton
Phulbani (MC)	OUAT, Bhubaneswar	Eastern Ghat Zone in Orissa (12.1)	Subhumid (Hot moist)	1580	Oxisols	Rice
Rajkot (MC)	JAU, Junagarh	North Saurashtra zones in Gujarat (5.1)	Semiarid (Hot dry)	590	Vertisols	Groundnut
Rakh Dhiansar (SC)	SKUAS_T, Jammu	Low altitude subtropical zone in Jammu and Kashmir (14.2)	Semiarid (Moist dry)	860	Inceptisols	Maize
Rewa (MC)	JNKVV, Jabalpur	Keymore plateau and Satpura Hill zone in Madhya Pradesh (10.3)	Subhumid (Hot dry)	1088	Vertisols	Soybean
S.K.Nagar (MC)	SDAU, Dantewada	Northern Gujarat in Gujarat (2.3)	Semiarid/Arid (Hot dry)	670	Entisols	Pearlmillet
Solapur (MC & ORP)	MPKV, Rahuri	Scarcity zone in Maharashtra (6.1)	Semiarid (Hot dry)	732	Vertisols	*Rabi* Sorghum
Varanasi (MC)	BHU, Varanasi	Eastern Plain and Vindhyan Zone in U.P. (4.3 / 9.2)	Semi arid (Hot moist) Subhumid (Hot dry)	1049	Inceptisols	Rice

MC- Main Centre; SC – Subcentre; ORP – Operational research Project

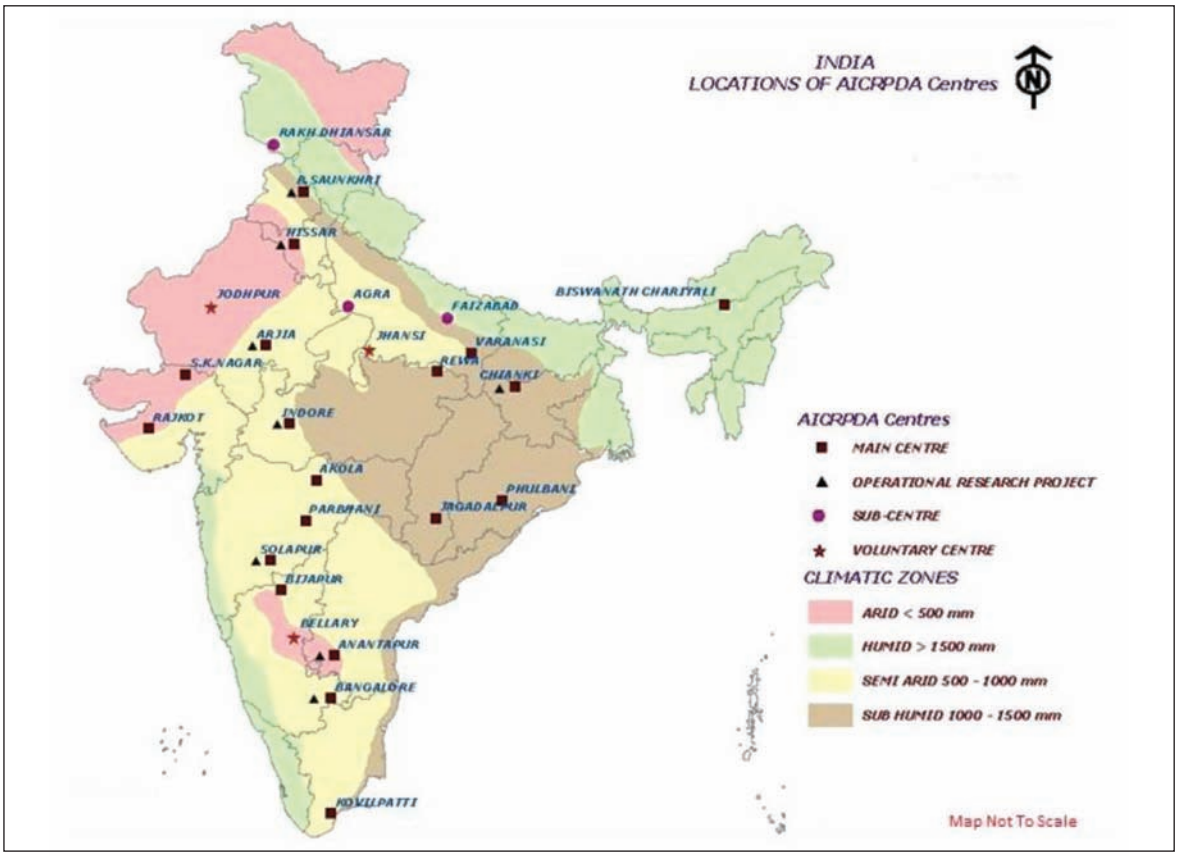

Fig. 1 : AICRPDA Network Centres - Location map

administrative and auxiliary). The research under AICRPDA network centers focuses on location specific problems considering agroecological characteristics, predominant rainfed production systems and socioeconomic settings with specific emphasis on soil conservation and rainwater management, evaluation of crops/varieties, cropping/farming systems and contingency planning, integrated nutrient management, tillage and farm machinery and alternate land use systems. In the last few years, more focus was given on cropping/farming systems, tillage and integrated nutrient management, alternate land use systems for diversification and efficient implements on a template of resource management particularly rainwater management. The on-station research findings generated at the centres were evaluated on farmers' fields in ORP watersheds/ villages. During this process of on-farm participatory research, other on-farm trials/ demonstrations and Front Line Demonstrations (FLDs) gave impetus for up scaling of rainfed technologies in the recommendation domain of the centres. Over a period of 3 decades, AICRPDA network centers generated location specific technologies for up scaling in the respective agroclimatic zones. These technologies basically address rain water harvesting and reuse for higher resource use efficiency and water productivity, efficient crops/varieties and cropping systems for higher yield and income, contingency crop planning, integrated nutrient management, bullock/tractor drawn farm implements for efficient tillage/seeding/fertilizer application/intercultural and other operations with cost effectiveness and timeliness, alternate land use systems for diversification, higher income and resource efficiency.

The technology demonstration component of NICRA in AICRPDA network envisages identifying climatic vulnerabilities of agriculture in the selected village in each of the 28 districts based on historical weather data from the nearest weather station, farmers' experiences and perceptions, preparing and implementing adaptation and mitigation strategies following a bottom-up approach. The focus of the program is not only to demonstrate the climate resilient agriculture technologies but also to institutionalize mechanisms at the village level for implementation of successful adaptation strategies on a sustainable basis. One

village or a cluster of villages from each of the 28 selected districts were selected for technology demonstration. The technology demonstration component in the selected districts is being piloted by the respective AICRPDA centers.

Climatic characteristics of the village: Once the village was selected, each center collected time series climatic/ weather data pertaining to the selected village or from the nearby weather station in order to understand the extent of vulnerability of the village's agriculture to climatic variability. The information was collected and analyzed related to the following:

Rainfall-annual as well as during Kharif season: Normal; trend in past 10 years (if any) increase/decrease.

Number of rainy days (seasonal as well as annual): Overall average, decadal average (1971-80, 1981-90, 1991-2000, 2001-09).

Intensive rain-spells (above 60 mm per day): Decadal average (1971-80, 1981-90, 1991-2000, 2001-09).

Number of dry-spells in past 10 years: Exceeding 15 days, exceeding 10 days in the *Kharif* season as well as in the whole year.

Length of growing season: Changes during past one decade

Number of floods severely/ completely damaging crops and livestock: Decade-wise number for the past three decades

Other extreme events: Information on damage (number. of events decade-wise for the past 3 decades) due to other weather extremities such as frost, heat and cold waves, hail storm, sea inundation of agricultural fields and consequent problems, information if any, on soil degradation due to extreme weather events.

Participatory appraisal of the village: The objective of the participatory appraisal of the village was to understand the farming systems, resource situation, constraints and climatic vulnerabilities and to identify opportunities of climate change adaptation and mitigation in the selected village. Every center collect information on land use pattern, area, production and productivity of different agricultural and horticultural crops, livestock composition and production, fishery production, awareness level of farmers about climate change, ground water level and its use, income from agriculture and allied activities, level of risk of crop loss due to climatic variability in the past one decade. This information was collected from the farmers and village key informants. The participatory appraisal was undertaken as follows:

Assessment of natural resource status: To understand as to why the agriculture in the selected village remains vulnerable to climatic change, it was planned to assess the status of natural resources, socio-economic, institutional and infrastructural status and major farming systems. The status of natural resources may cover type, quality, organic matter status and depth of soil and its suitability for different crops, access and level of use of manure (FYM & green) and fertilizers, scope for improving organic matter in soil, access to water-rainwater (if harvested), ground water (open wells and bore wells and whether level is declining) and canal water (timely availability and access); account of major changes in flora and fauna during past one decade and its causes. Such assessment was useful to plan NRM related interventions.

Socio-economic status institutional arrangements: The centers were suggested to collect information on land holding structure, level of income, literacy and education of farmers, asset base of farmers, participation in social networks, proportion below poverty line, access to critical inputs to agriculture and marketing opportunity for farm output, access to market information and technical knowledge, level of awareness and skills of farmers, access to different Govt. schemes, existing institutional arrangements like SHGs, commodity groups, user groups and their effectiveness, etc. Based on the social dynamics in the village, different institutional arrangements were planned to implement the project activities.

Major farming systems: The information was collected on land use pattern, extent of irrigation, type of crops and varieties grown, yield levels, level of input use (fertilizer, manure, pesticides, weedicide, etc), seed replacement rate in major crops, level of mechanization for different farm activities, system of irrigation (flood, drip, sprinkler), access to farm machines (owned/ custom hiring), access to improved seed, livestock species reared and their yields, incidence of various diseases in the livestock and consequent mortality and changes in cropping/ farming systems during the past one decade. This analysis helped in planning appropriate climatic resilient technological interventions for individual as well as group of farmers.

Constraint Analysis: The multidisciplinary team analyzed the constraints related to climatic variability based on secondary weather data, resource situation, farming systems and agricultural yields in the past few years. The major constraints resulting from climatic variability includes; water scarcity, recurrent droughts (early, mid season, terminal), cold wave, heat wave, flood, pest and diseases of crop and livestock, fodder scarcity, poor access to appropriate seeds/planting material and critical inputs and farm machinery (timeliness and cost of access). The constraints were supposed to be analyzed by the multidisciplinary team in a manner so that the actual causes of constraints and points to intervention are identified.

Climate resilient technology demonstrations proposed by AICRPDA centers

Each center proposed technological and institutional interventions for enhancing the resilience of farming systems to the climatic variability by involving the major stakeholders such as farmers, researchers, NGOs, officers of the line departments and extension specialists. Based on the detailed analysis of farming systems, resources, constraints, needs of the village, the climatic vulnerability (drought/floods/heat wave/frost/cyclone) and the available technology options from the concerned Regional /Zonal Agricultural Research Stations of the SAU and ICAR institutes and time tested climate resilient farm practices adopted by innovative farmers, the stakeholders in the brainstorming sessions identified the gaps and selected specific interventions related to each of the four sub-projects (i) Real time contingency plan implementation in a participatory mode (ii) Rainwater harvesting *(in-situ and ex-situ)* and efficient use (iii) Efficient energy use and management (iv) Alternate land use. It was planned to saturate the whole village with the identified interventions in order to demonstrate a discernable effect and document the constraints and lessons. Further the preference was given to the interventions targeted/ focused on the following:

- Interventions benefiting larger and resource poor group
- Interventions which give long-term and sustainable benefits
- Interventions that address resource conservation
- Interventions that promote/strengthen village level institutions

Coverage of the program

Finally the whole village was to be saturated with the climate resilient technologies; however, in the beginning the number of interventions of different types were decided as per the budget available, vulnerability status and cooperation of the farmers. The interventions which require high investment like farm pond were planned for few suitable locations in the village. The *in-situ* moisture conservation and improved agronomic practices, inter-cropping and new varieties were planned to be taken up for large number of farms in the village. In selection of beneficiaries, the farmers' most vulnerable to climatic variability and small holders were given priority. It was also ensured that the village has control farm/plot/animals for all the implemented interventions in order to assess the impact of interventions in a short period. Every centre was suggested to prepare the activity plan with details of activities along with roles and responsibilities of stakeholders, period and budget for each intervention. The AICRPDA Network centers have been included in the National Initiative on Climate Resilient Agriculture (NICRA) Project of ICAR for taking up demonstration and research activities at various dryland centers in a network mode. The demonstration components of NICRA have been finalized in these centers in a participatory mode. The villages in districts and domain districts of the centers are given in (Table 2) and location of the adopted villages is shown in (Fig. 1a).

During 2011-12, demonstration of an integrated package of proven rainfed technologies was conducted in selected villages at 23 AICRPDA Centers for adaption of crop production system to climate variability. The demonstrations covered a total area of 1980.88 ha covering 3495 farmers. The trials were conducted in 40 villages in 26 districts. There were four sub-projects, viz., 1) Real time contingency plan implementation in a participatory mode, 2) Rainwater harvesting *(in-situ and ex-situ)* and efficient use, 3) Efficient energy use and management & 4) Alternate land use / farming systems for carbon sequestration and ecosystem services. The trials were conducted in order to evaluate the performance of improved practices compared to the farmers practice for different rainfed crops of cereals, pulses, oilseeds, vegetables and other commercial crops to cope with current climate variability.

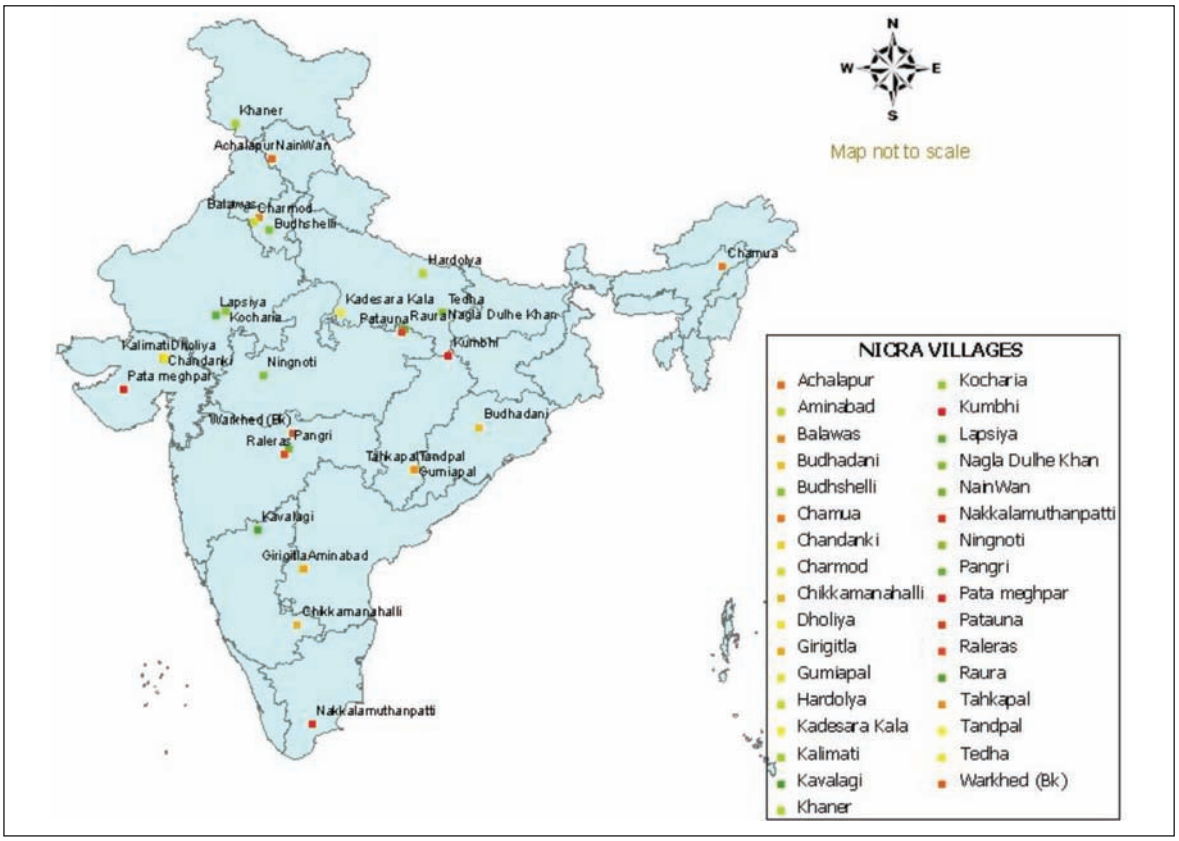

Fig. 1a : NICRA villages adopted by AICRPDA centers - location map

The Programme Implementation: Process

The process of implementation of on-station experiments at the AICRPDA centres and on-farm demonstrations in the villages adopted by the centres under NICRA are presented below:

The major interventions were implemented both under on-farm and on-station, broadly under four theme areas as follows:

I. Real time contingency crop plan implementation both on station and on farm in a participatory mode

- To sustain the productivity of pearlmillet, clusterbean, sesame under normal are drought conditions
- To improve the productivity of mustard, chickpea and wheat under rainfed conditions

II. Rain water harvesting (in-situ and ex-situ) and efficient use

- Demonstration on efficient in-situ moisture conservation practices to conserve more moisture (ridge and furrow planting, compartmental bundling etc.)
- Efficient and multiple use of harvested water or enhancing water use efficiency (life saving irrigation, sprinkler irrigation)
- Ground water recharging through bore well and open well, defunct well

III. Efficient energy use and management

- Introduction of modern machines and to create awareness in the farming community about their use for different crops (establishing custom hiring centre and ensuring services in the village)

IV. Alternate land use for carbon sequestration and eco-system services

- To develop alternate land use system / farming system for carbon sequestration and ecosystem services

The package included land configuration, crops or varieties/cropping system, rain water harvesting and recycling, timely operations through custom hiring centre and alternate land use and ecosystem services.

Table 2. Details of villages under NICRA program

Name of the center	Name of the Village(s)	District	State	Total cultivated area (ha)	Rainfed area (%)
Agra	Nagla Duleh khan	Agra	Uttar Pradesh	981	90
Akola	Warkhed, Belura	Akola	Maharashtra	275	92
Anantapur	Aminabad, Girigetla	Kurnool	Andhra Pradesh	167.5	74
Arjia	Kocharia, Mandpiya, Sola ka kheda, Lapsiya, Tara ka kheda	Bhilwara Rajsamand	Rajasthan	540	77
Ballowal Saunkhri	Naiwan, Achalpur	Hosiarpur	Punjab	465.2	84
Bengaluru	Chikkamaranahalli (Chikkamaranahalli colony, Chickaputtyanapalya, Hosapalya, Mudalapalya)	Bengaluru Rural	Karnataka	409.2	90
Bijapur	Kaulagi	Bijapur	Karnataka	1327	98
Biswanath Chariali	Chamua	Lakhlmpur	Assam	133	100
Chianki	Khumbhi - bankheta	Garhwa	Jharkhand	215	70
Faizabad	Hardoiya	Faizabad	Uttar Pradesh	397	35
Hisar	Budhsheli, Charnod, Balawas	Bhiwani	Haryana	2203	77
Indore	Ningnoti	Indore	Madhya Pradesh	248	40
Jagdalpur	Tahakapal, Gumiapal, Pahkapal	Bastar	Chittishgarh	511.25	98
Jhansi	Kadesara Kala	Lalitpur	Uttar Pradesh	875.10	33
Kovilpatti	Nakkalamuthanpatti, Kalugachalipuram	Tuticorin Thoothukkudi	Tamil Nadu	630.65	92
Parbhani	Pangri	Parbhani	Maharashtra	951.06	93
Phulbani	Budhadani	Kandhamal	Orissa	101.21	81
Rajkot	Pata meghapar	Jamnagar	Gujarat	2793	60
Rakh Dhiansar	Khaner	Rakh Dhiansar	Jammu & Kashmir	55	100
Rewa	Patauna	Rewa	Madhya Pradesh	743.986	34
SK Nagar	Dholia, Kalimati, Chandanki	Banaskantha, Mehasana	Gujarat	1100.9	68
Solapur	Raleras	Solapur	Maharashtra	560.7	80
Varanasi	Terha Saraya	Mizapur	Uttar Pradesh	290	72

*** One village with 4 clusters**

1 Salient Achievements
Technology Demonstration

1. 1. Rice Based Production System

1.1.1 BISWNATH CHARIALI

a. Agro-ecological setting

Biswnath Charilai centre is located in middle Brahmaputra plain eco-subregion (AESR 15.2). The climate is hot humid. Annual normal rainfall is 1990 mm. The length of growing period is 240 to 270 days. Seasonal flooding and water logging is common which demands special selection for normal crop husbandry.

b. On-station experiments

At Biswnath Charilai, the onset of monsoon was during first week of June as like normal onset. A rainfall of 1442.8 mm was received during cropping period against normal of 1302.2 mm in 2011 (Fig. 2). There was an excess rainfall of 34.5, 52.5, 26.5 and 14.6 per cent during July, August, September and November respectively over normal rainfall of these months. However, 48.1, 32.1 and 100 per cent deficit rainfall was received during June, October and December respectively.

Development of Dryland Technology Park: Initiative had been taken to develop a 'Dryland Technology Park' at BN College of Agriculture under NICRA project during 2011-12. Initially the area was developed capacity building for research, production and instructional purposes. Presently the Dryland Technology Park is being maintained and strengthened under NICRA project for demonstration of climate resilient agro-technologies.

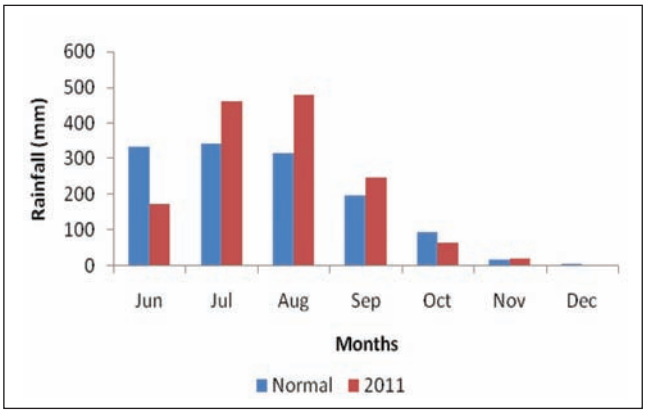

Fig. 2 : Normal and actual (2011) monthly rainfall at Biswnath Charilai

Infrastructures/facilities developed at Dryland Technology Park, NICRA, AICRPDA, Biswanath Charilai are given Table 3.

Table 3 : Infrastructures/facilities developed at dryland technology park , AICRPDA, Biswanath Charili

Facilities developed	No of units/ area	Remarks
Azolla production unit	32	-
Vermicompost production unit	20	-
Low cost vermicomposting unit	20	-
Compost production unit	10	-
Storage cum processing unit	1	-
Cow-dung storage unit	1	-
Poly-house	1	In progress
Rooftop rain water harvesting structure	1	In progress
Mushroom production unit	1	In progress
Honeybee production unit	3	In progress
Rain water harvesting structure	1	
Rainwater harvesting structures for testing various sealing materials for enhancing rain water storage capacity	9	In progress
Demonstration of drip irrigation in banana	0.15 ha	

c. On-farm experiments

Village profile

The program is being implemented at the village Chamua Narayanpur in Lakhimpur district of Assam. The total cultivated area is 133 ha out of which 133 ha is rainfed. The mean annual rainfall is 1987 mm with seasonal rainfall of 1262 mm during *kharif* (June-September). The major soil types are Inceptisols (sandy loam to silty clay loamy with pH ranges from 4.65 to 6.38)

The major crops during *kharif* under rainfed are *Sali* rice, sesame, blackgram, greengram, summer vegetables etc and *rabi* are rapeseed, potato, winter vegetables etc. The numbers of small, marginal, medium and large farmers are 41, 65, 19 and 0, respectively. The ground water table is 6m.

Climate Variability in General

In general, the climate in this agro-climatic zone is humid. The south-west monsoon contributes 64.5%, north-east monsoon 7.7%, summer 24.8% and winter 3.1% of the total annual average rainfall of 1987 mm. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon 30-40% deficit of the average rainfall. The onset (south-west) of monsoon is during 23 SMW (standard meteorological week). Early season drought or normal onset of monsoon followed by 15 to 20 days dry spell and mid season drought are recurrent. The dry spells or flood during crop season are experienced for the past 15 years during July, August, September and October at tillering, panicle initiation, reproductive growth stages of the *Sali* rice. The onset of the monsoon is normal. The soil moisture status is deficit during tillering, panicle initiation and reproductive stages of *Sali* rice. The data on maximum/minimum temperature during crop season is increasing (maximum temperature by 0.006^0C/year and minimum by 0.0194^0C/year) either decreasing or increasing in past 50 years. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* (June, July, August and September and October) and *rabi* seasons. The area is also experiencing other extreme events like flood, hail storm, thunder storm.

Experienced weather conditions during 2011-12

The village received 1178 mm which was deficit of 103 mm compared to normal (1281 mm) during south-west monsoon (*kharif*). The onset of monsoon was 15-20 days delayed. The crops experienced dry spells during 27 & 28 SMW (July), 32 & 35 SMW (August), 36, 39 SMW (September), 41& 44 SMW (October) at tillering, Panicle initiation and grain filling stages of *Sali* rice. The intense rainfall events were experienced 2nd July (108 mm), 15 August (53), 17 August (171 mm), 21 August (66 mm) 9 September (54 mm) and 15 September (66 mm). These events impacted the stand/ performance of *Sali* crop adversely due to flash flood during August.

Interventions

The major interventions included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 60 ha in 20 farmers' fields.

Land configuration

The land configuration included compartment bunding which facilitated runoff modulation/improved the drainage and enhanced *in-situ* moisture conservation. This resulted in mitigating dry spell and enhanced the crop yield of *Sali* rice.

Crops/ Varieties/Cropping system

Under this component, the suitable varieties of rainfed crops like Luit, Kapilee, Lachit, Dishang, Dihangi, Kolong etc (short duration) and Satyaranjan and Basundhara (medium duration) of *Sali* rice during *kharif* and Kufri Pokhraj (Short duration) were introduced to cope with the rainfall variability of the region.

a) **For delayed onset of monsoon (South-West/North-East) –** *Sali* rice was not affected due to delayed of onset of monsoon during 2011. Only 1/10th of total area is required for sowing seeds of *Sali* rice. Though onset of monsoon was delayed by about 15 days, sowing was not affected as timely sowing was possible because of using pond water lifted by water lifting pump (diesel engine) of the custom hiring centre of the village.

b) **For dry spell (during *kharif*) *Sali* rice:** Short and medium duration cultivars were proved to be better under the condition of prevailing midseason and terminal dry-spells.

c) **Crop diversification:** Instead of growing only *Sali* rice (Fig. 3), crop diversification was proved to be advantageous under water stress condition. With same rainfall and soil resources diversified cropping performed well as compared to mono-cropping. For example, Mr. Harendra Neog, a marginal farmer earned only Rs. 15000/ ha/annum (farmer practice) as *Sali* rice crop was adversely affected by multiple mid season and terminal dry-spells during 2011. However, he was able to earn much higher income (Rs. 150,000.00/ha/year) (Table 4) from the same type soil and rainfall amount when many crops were grown more than 15 crops (Fig. 4). Rice cv. Jalshree performed better under submergence condition (Fig. 5).

Table 4 : Impact of Crop diversification under delayed onset of monsoon and mid season drought

Crop	Improved practice (Diversified cropping)		BC ratio	Farmers practice (Growing local cultivar)		BC ratio
	Variety	Yield (kg/ha)		Crop (variety)	Yield	
Rice	Basundhar	3718	1.7	Rice (Jaha)	825*	1.04
Turmeric	Local	67500	21.4	(A scented local variety)		
Ginger	Local		14.6			
Potato	K. Pokhraj	32500	4.5			
Rapeseed	TS-36	911	1.69			
Napier	Hy Napier	5000				
Arhar	Biswanath Collection					
Black gram, French bean, sesame, bhendi, cow pea etc						

*Rate :Rs. 18.00/kg

Fig. 4 : Improved Practice - diversified cropping

Fig. 3 : Farmers Practice - mono cropping

Fig. 5 : Before and after submergence in main field

Rainwater harvesting and recycling

The existing farm ponds in the village is of size 25 x 25 x 1.5 $m^3$and 25 x 30 x 1.5 m^3 were renovated. The stored water in the farm pond during this year was efficiently utilized for supplementary irrigation of 9.4 cm during stolon formation and tuber growth stages of Potato and flower bud initiation/flowering of rapeseed (Table 5). (Fig. 6a, 6b, 6c).

Table 5 : Performance of potato and rapeseed with supplemental irrigation from the harvested rainwater

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Increase in net returns (Rs/ha)	BC ratio
		Supplementary irrigation/	Without irrigation			
Potato	Kufri Pokhraj	26750	12100	121	1,09,475.00	1.76 to 3.87
Rapeseed	TS-36	756	496	52.3	6300.00	1.21 to 1.82

Fig. 6a : Rainwater harvesting and efficient utilization through water lifting pump and sprinkler irrigation

Fig. 6b : Good crop of potato and rapeseed with suplemental irrigation from harvested rainwater (farm pond)

Fig. 6c : Performance of potato and rapeseed without supplimental irrigation

Timely operations through Custom Hiring Center

The centre has taken initiative and developed guidelines for village climate risk management committee. A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements include diesel engine operated water lifting pump (WLP), reaper, thresher, sprayers, rotavator, cultivator, disc harrow, dry weeder gave higher output energy and crop yield compared to normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period. Better rice yields and energy output achieved with thresher and reaper (Fig. 7a, 7b, 7c) (Table 6).

Alternate land use and Eco-system services

Fish + duck + pig + agri-horti system with potato/ termeric/ginger/maize + coloca ciaetc were demonstrated in farmers' fields.

Table 6 : Efficient energy (MJ) management with improved implements

Implement	Crop	Variety	Energy (MJ) for improved implement		Energy (MJ) for normal implement		Increase net returns (Rs/ha)	BC ratio
			Input	Output	Input	Output		
Thresher	Rice	Ranjit	8890	70560	9103	70560	1500.00	1.91 to 2.10
Reaper	Rice	Ranjit	8844	70560	9103	70560	2600.00	1.91 to 2.20
WLP	Potato	Pokhraj	-	-	-	-	89025.00	2.24 to 3.87
WLP	Rape-seed	TS-36	-	-	-	-	6300.00	0.99 to1.37

WLP - Water lifting pump

Fig. 7a : Thresher in operation

Fig. 7b : Farmers' practice

Fig. 7c : Better harvest of rice crop with reaper

1.1.2 CHIANKI

a. Agro-ecological setting

Chianki centre is located in Chattisgarh Mahanadi basin (11.0) and western plateau zone in Jharkhand. The climate is hot moist sub-humid. Annual normal rainfall is 1179 mm. The length of growing period is 150-180 days. The annual normal potential evapotranspiration is 1400 - 1600 mm. In some parts of the region, partial water logging in early stages of the crop growth followed by seasonal drought during the rest of the period is noticed. In some parts of the region, sub-soil graveliness limits root ramification.

b. On-station experiments

At Chianki, the onset of monsoon was during third week of June i.e. delayed by 13 days as compared to normal onset. A rainfall of 1344 mm was received during cropping period against normal rainfall of 1149 mm in 2011. There was an excess rainfall of 138.2, 32.5 and 7.5 per cent over normal during June, August and September, respectively. However, July, October, November and December months recorded 34.3, 66.1, 100 and 100 per cent deficit rainfall, respectively over normal rainfall (Fig. 8). There were 54 rainy days during cropping period.

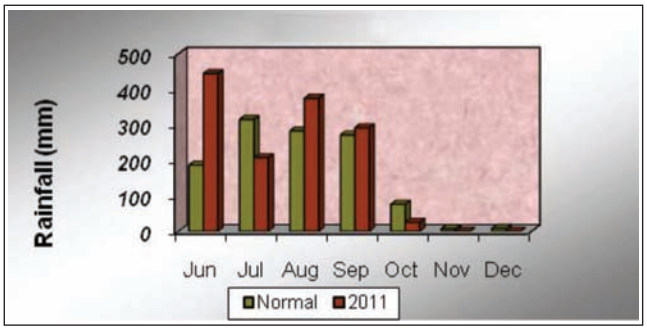

Fig. 8 : Normal and actual (2011) monthly rainfall at chianki

Real time contingency crop planning

Performance of drought tolerant varieties of upland rice under delayed onset of monsoon

Seven cultivars of rainfed upland rice *viz*., RR-616-B-2-75-2, Vandana, BVD-108, BVD-109, BVD-110, BVD-111 and Bakar Dhan (LC) which are developed from various Rice Research Institutes, were evaluated, RR-616-B-275-2 yielded (2600 kg/ha) significantly superior followed by Vandana which is drought tolerant variety has given (2203 kg/ha). RR-616-B-275-2, a lowland rice variety could be suitable under delayed onset of monsoon to cope with the variability in rainfall (Table 7).

Performance of drought tolerant varieties of rice for medium land situation and delayed onset of monsoon

Eight entries of medium land transplanted rice were evaluated out of which Naveen was significantly superior and yielded (5916 kg/ha) followed by entry 27 -P-31 (5466 kg/ha). The Naveen and 27 -P-31 medium land transplanted rice varieties performed better when the onset of monsoon was delayed by 13 days (Table 8).

Table 7 : Performance of drought tolerant varieties of upland rice under delayed onset of monsoon

Variety	Grain yield (kg/ha)	Days to 50% flowering	Days to Maturity	Plant ht. (cm)	Panicle length (cm)	No. of filled grain/ Panicle	Unfilled grain/ panicle	1000 grain wt.(g)
RR-616-B-2-75-2	2600	70	87	120	21	176	14	24
Vandana	2203	62	90	118	20	164	15	22
BVD-108	1406	55	76	120	19	134	20	23
BVD-109	1903	60	75	116	19	147	18	22
BVD-110	1760	75	93	118	19	140	20	24
BVD-111	1900	60	78	119	18	147	18	22
Bakar Dhan (LC)	1790	66	84	81	19	140	14	23
CD (5%)	3.88							
CV (%)	11.79							

Table 8 : Performance of drought tolerant varieties of rice under delayed onset of monsoon for medium land situation

Variety	Grain yield (kg/ha)	Days to 50% flowering	Days to Maturity	Plant ht. (cm)	Panicle length (cm)	No. of filled grain/ Panicle	Unfilled grain/ panicle	1000 grain wt.(g)
Naveen	5916	67	118	113	27	226	10	24
Sahbhagi	5283	62	117	107	25	168	19	23
PAC-801	5266	65	117	102	25	167	14	21
PAC-807	4850	50	94	102	26	161	16	23
27P-31	5466	70	119	102	26	175	20	23
IR-36 (C)	4216	58	105	97	23	139	20	24
Tej	4566	69	116	101	25	151	21	24
RH-527	4883	67	115	95	25	161	25	23
CD (5%)	5.24							
CV (%)	5.92							

Performance of drought tolerant varieties of rice for lowland situation

Six varieties of lowland transplanted rice *viz*., MTU-7029, BPT-5204, Rajshree, MTU-1001, Arize-6444 and Birsamati were evaluated. Arize-6444 produced highest yield (6016 kg/ha) followed by Rajshree (6000 kg/ha) and MTU 7029 (5500 kg/ha.). Arize-6444 and Rajshree rice varieties performed better under lowland conditions when the onset of monsoon was delayed by 13 days in this region (Table 9).

Performance of drought tolerant high yielding varieties of maize under delayed onset of monsoon and under excess and deficit rainfall situation

Five genotypes of maize *viz*., Yamunotry 555, BVM-2, Suwan – 1, HQPM -1 and Kanchan were evaluated, out of which Kanchan gave significantly highest yield (4013 kg/ha) followed by Yamunotry-555 (3744 kg/ha). Under delayed onset of monsoon, Kanchan variety could be used for sowing to cope with the climate variability in this region (Table 10).

Table 9 : Performance of drought tolerant varieties of rice for lowland situation

Variety	Grain yield (kg/ha)	Days to 50% flowering	Days to Maturity	Plant ht. (cm)	Panicle length (cm)	No. of filled grain/ Panicle	Unfilled grain/ panicle	1000 grain wt.(g)
MTU-7029	5500	102	140	92	24	234	27	24
BPT-5204	4550	98	139	106	25	217	19	21
Rajshree	6000	96	135	115	26	231	18	22
MTU-1001	4950	97	138	102	24	199	20	24
Arize-6444	6016	92	135	107	26	244	17	22
Birsamati	5083	98	138	114	25	233	17	22
CD (5%)	7.71							
CV (%)	8.17							

Table 10 : Performance of drought tolerant varieties of maize under excess and deficit rainfall situation

Variety	Grain yield (kg/ha)	Days to 50% flowering	Days to Maturity	Plant height (cm)	Cob length (cm)	Cob girth (cm)	No. of row/ Cob	100 Seed weight (g)
Yamunotry 555	3744	61	105	212	18	14.25	16	31
BVM-2	3562	56	100	223	16	15.00	13	23
Suwan - 1	3500	60	102	203	16	15.25	14	29
HQPM -1	3663	64	107	209	17	16.50	16	29
Kanchan	4013	59	107	231	18	15.25	17	32
CD (5%)	3.12							
CV (%)	8.49							

Performance of drought tolerant varieties of pigeonpea under delayed and mid season drought situation

Four varieties including Birsa Pigeonpea-1 and Local (Farmer genotype) were evaluated in which Birsa Pigeonpea-1 gave significantly highest yield (1770 kg/ha). Therefore, under delayed onset of monsoon, Birsa Pigeonpea-1 variety could be used for sowing to cope with the climate variability in this region (Table 11).

Performance of drought tolerant varieties of sesame under delayed onset and mid season drought situation

Five varieties of sesamum *viz*., Kanke White, Shekhar, G-9 (Durga), C-10 Sarthi and Local were tested for suitability in sub-zone V in which Shekhar (459 kg/ha) gave significantly highest yield. Shekaer variety of sesamum found be highly suitable for this region under late onset of monsoon by 13 days (Table 12).

Table 11 : Performance of drought tolerant varieties of pigeonpea under delayed onset and mid season drought situation

Variety	Seed yield (kg/ha)	Days to 50% flowering	Days to maturity	Plant height (cm)	No.of Pods/ plant	No.of Seeds/ pod	100 Seed weight (g)
IPCH-2671	1520	128	187	195	275	3	10
Birsa Pigeonpea-1	1770	128	197	201	317	3	10
Asha	1680	129	201	201	307	3	10
Local	1205	136	215	206	215	5	9
CD (5%)	2.69						
CV %	12.58						

Table 12 : Performance of drought tolerant varieties of sesame

Variety	Seed yield (kg/ha)	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of Branch/ plant	No. of Capsule/ Plant
Kanke White	414	37	95	112	2.7	56
Shekhar	459	36	94	112	2.9	60
G-9 (Durga)	368	37	94	126	2.8	49
C-10 Sarthi	349	38	94	113	3.2	39
Local	323	38	94	113	3.0	37
CD (5%)	0.33					
CV (%)	5.68					

Performance of high yielding varieties of horsegram under delayed onset of monsoon

Five varieties of horsegram *viz*., Birsa Kulthi-1, GHG-19, GHG-13, Madhu (Check) and AK-21were evaluated in which Birsa Kulthi-1 gave highest yield (812 kg/ha) followed by AK 21 (551kg/ha). Under late onset of monsoon, Birsa Kulthi-1 variety of horsegram performed better and found to be highly suitable for this region (Table 13).

Performance of high yielding varieties of niger for rainfed upland situation

Four genotypes of niger were aevaluated, out of which BN-3 gave significantly highest yield (499 kg/ha) followed by Birsa Niger-1 (422 kg/ha). BN-3 variety of niger found to be more suitable under delayed onset of monsoon by 13 days (Table 14).

Performance of pigeonpea based intercropping system under delayed onset of monsoon

The maximum pigeonpea equivalent yield was recorded in pigeonpea + okra intercropping system (31.32 kg/ha) which was significantly superior to all other intercropping system i.e. pigeonpea + sorghum and pigeonpea + maize (Table 15).

Performance of different varieties / hybrids of chickpea under mid season drought

Four improved varieties/ hybrids of chickpea *viz*., KAK-2, Annegiri, KPG-59, BG-3 and Local were evaluated. KPG-59 significantly yielded (834kg/ha) followed by BG-3 (726 kg/ha) (Table 16).

Performance of varieties / hybrids of lentil under mid season drought

Four varieties of lentil varieties *viz*., PL-406, PL-639, DPL-62 and KLS-28 were evaluated along with local. Out of which PL-639 (71 kg/ha) followed by PL-406 (672 kg/ha) (Table 17).

Performance of different varieties of mustard under mid season drought

Four improved varieties of mustard *viz*., Shivani, Pusa bold, Kranti and Vardan were evaluated along with local. Out of which Pusa bold was significantly superior to all entries and yielded (695 kg/ha) followed by Shivani (521 kg/ha). Under delayed onset of monsoon, Pusa bold of mustard found to be better variety to cope with the climate variability of the region (Table 18).

Table 13 : Performance of high yielding varieties of horsegram under delayed onset of monsoon

Variety	Seed yield (kg/ha)	Days to 50% flowering	Days to maturity	Plant height (cm)	No of pod/ plant	No. of seed / pod	100 Seed wt. (g)
Birsa Kulthi-1	812	44	94	37	24	4.0	3.3
GHG-19	443	38	86	38	25	3.5	3.1
GHG-13	395	39	86	38	25	3.5	3.2
Madhu (Check)	458	41	90	39	24	4.0	3.3
AK-21	558	45	84	37	25	4.1	3.2
CD (5%)	1.86						
CV (%)	18.95						

Table 14 : Performance of high yielding varieties of niger for rainfed upland situation

Variety	Seed yield (kg/ha)	Days to 50 flowering	Days to maturity	Plant height (cm)
BN-1	422	55.2	107.6	105.6
BN-2	313	51.6	110.4	98.6
BN-3	499	52.4	113.2	104.04
Puja	316	52.6	107.2	101.6
CD (5%)	0.6664			
CV (%)	12.43			

Table 15 : Performance of pigeonpea based intercropping system under delayed onset of monsoon and mid season drought

Treatment	Seed Yield (kg/ha)	Pigeonpea equivalent yield (kg/ha)	Plant height (m)	Pods/ Plant	Seeds/ Pod
Sole Pigeonpea	2150	2150	2.53	285.6	4.0
Pigeonpea+ maize	1910	2276	2.36 (1.58)	238.8	3.8
Pigeonpea+ okra	1855	3132	2.24 (1.44)	200.9	3.8
Pigeonpea+ sorghum	1766	2212	2.23 (2.50)	176.6	3.6
Sole Sorghum	2265	-	2.58	-	-
Sole Okra	9100	-	1.42	-	-
Sole Maize	3244	-	1.73	-	-
CD (5%)		3.24			
CV (%)		11.21			

Table 16 : Performance of different varieties / hybrids of chickpea under mid season drought

Variety	Seed yield (kg/ha)	Days to 50 % flowering	Days to Maturity	Plant ht. (cm)	No of primary branches	No of pod / plant	100 seed wt.(g)
KAK-2	684	57	103	29.2	4.0	20.5	130.1
Annegiri	562	61	107	31.8	3.9	18.4	117.0
KPG-59	834	71	129	27.0	5.0	29.5	116.2
BG-3	726	65	124	28.6	4.8	24.0	118.1
Local	477	64	125	26.3	3.7	14.5	110.0
CD (5%)	0.644						
CV (%)	6.37						

Table 17 : Performance of varieties / hybrids of lentil under mid season drought

Variety	Seed yield (kg/ha)	Days to 50% flowering	Days to Maturity	Plant ht. (cm)	No of primary branches	No of seconddary branches	No of pod / plant	1000 grain wt.(g)
PL-06	672	50	102.5	28.3	6.3	7.9	47.3	26.1
PL-639	710	49	101.3	28.0	6.4	8.4	47.5	24.5
DPL-62	607	46	101.5	31.6	6.0	7.7	42.5	20.0
KLS-28	470	50	101.3	33.3	5.8	7.7	34.2	21.0
Local	433	50	107.3	31.5	5.4	6.6	31.8	24.0
CD (5%)	0.572							
CV (%)	6.42							

Table 18 : Performance of different varieties / hybrids of mustard under mid season drought

Variety	Grain yield (kg/ha)	Pl] height (cm)	No of primary branches	No of secondary branches	No of siliqua/ plant	No of grain / siliqua	1000 seed wt.
Shivani	521	103.5	4.6	7.2	87.4	10.4	29.9
Pusa bold	695	101.0	5.0	7.6	87.9	11.4	30.7
Kranti	446	100.1	4.1	7.1	72.9	9.4	29.5
Vardan	489	111.8	4.2	7.1	74.5	10.4	30.0
Local	377	96.5	3.7	7.0	46.3	7.9	29.0
CD (5%)	0.504						
CV (%)	6.47						

Nutrient management under late sown condition of chickpea

The chickpea cv. KPG-59 recorded the significantly highest yield (961 kg/ha) with 20:40:20 (N:P:K) kg/ha along with application of 2% urea solution at branching stage and pod initiation stage in chickpea (Table 19).

Table 19 : Nutrient management under late sown condition of chickpea

Variety	Seed yield (kg/ha)	Days to 50% flowering	Days to Maturity	Plant height (cm)	No of pod/ plant	100 grain wt (g)
V1F1(KPG-59 and 20:40:20 NPK)	762	70	126	29.2	25.2	11.5
V1F2 (KPG-59 and F1+2% Urea Solution at branching)	806	69	126	26.8	25.7	12.0
V1F3(KPG-59 and F1+2% Urea Solution at branching stage and pod initiation stage)	961	71	128	32.6	32.0	12.2
V2F1(JG-14 and 20:40:20 NPK)	588	58	109	29.4	18.8	10.8
V2 F2 (JG-14 and F1+ 2% Urea Solution at branching)	620	56	110	30.2	19.8	10.5
V2F3 (JG-14 and F1+2% Urea Solution at branching stage and pod initiation stage)	631	58	109	33	20.2	10.4
V3F1(KAK-2 and 20:40:20 NPK)	501	60	103	28.4	16.1.0	12.6
V3F2 (KAK-2 and F1+2% Urea Solution at branching)	538	59	101	29.6	17.2	13.0
V3F3(KAK-2 and F1+2% Urea Solution at branching)	545	58	102	28.2	17.4	12.2
CD (5%)	0.79					
CV (%)	6.93					

Alternate land use systems

Guava based agri-horti system was introduced during 2011. The crop component includes rice, rice + pigeonpea, maize, maize + pigeonpea, sorghum, sorghum + pigeonpea, pigeonpea

c. On-farm experiments

Village profile

The program was implemented by AICRPDA centre, Chianki in Kumbhi and Bankheta villages in Garhwa district, Jharkhand. The total cultivated area is 215 ha out of which 150 ha is rainfed. The mean annual rainfall is 1280 mm with seasonal rainfall of 1032 mm during *kharif* (June-September). The major soil types are Sandy loam, clay loam and loam. The major crops during *kharif* under rainfed are rice, maize, pigeonpea, sesame, etc and *rabi* are chickpea, wheat, lentil, linseed, mustard, etc. The number of small, marginal, medium and large farmers is 131, 69 and 27 respectively. The source of irrigation is rainwater harvested (dam and ahars) covering 30% of cultivated area.

Interventions

The major interventions were implemented both under on-farm and on-station included land configuration, rainwater harvesting and recycling and timely operations through custom hiring center. These interventions covered an area of 55.04 ha in 486 farmers' fields.

Land configuration

The land configuration includes ridge furrow system which facilitated runoff modulation/improved the drainage and enhanced *in-situ* moisture conservation. This resulted in mitigating dry spell and enhanced the maize yield (Fig. 9a, 9b) and rainwater use efficiency by 46.96% and RWUE by 4.38% respectively compared to maize sown with flat bed system (farmers practice) (Table 20)

Table 20 : Effect of improved practice (land configuration) in maize

Crop	Variety	Grain Yield (kg/ha)		% increase	RWUE (kg/ha/mm)	BC ratio
		Improved practice	Farmers' practice			
Maize	HQPM-1	4287	2917	46.96	4.38	2.85

Fig. 9a : Performance of HQPM-1 maize with ridge furrow system

Fig. 9b : Maize with flat bed planting

The existing farm pond in the village, is of size 300 x 250, was renovated. The stored water in the farm pond during this year was efficiently utilized and will be used for supplementary irrigation/life saving irrigation of 25 ha x 5 cm during growth stages of the *rabi* crop.

Stored water from rainwater harvesting in dam (reservoir) in the village was not utilized due to continuous flow and the entire 40 ha downstream cultivated land was wet till December. Rice was harvested with delayed or harvested operation and hence *rabi* cultivation was not possible. Due to efforts under NICRA with farmers participation, the gate was repaired in last June which regulated water supply from dam time to time and resulted in bringing net 25 ha land under cultivation further leading to cropping intensity. The intervention benefited largely the farmers of the NICRA village (Kumbhi and Bankheta) (Fig. 10).

Fig. 10 : View of renovated water harvesting structure in NICRA Village (Kumbhi and Bankheta)

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements made available were rotovater, cultivator, disc plough, MB Plough gave higher output energy and crop yield compared to normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period.

1.1.3 FAIZABAD

a. Agro-ecological setting

Faizabad center is located in northern plain, Rohilkhand, Avadh and south Bihar plains (AESR 9.2) and Easten plain agroclimatic zone in Uttarpradesh. The climate is hot dry sub-humid. Annual normal potential evapo-transpiration is 549 mm. Annual normal rainfall is 1054 mm. Length of growing period is 150-180 days. Drought occurs once in ten years.

b. On-station experiments

A rainfall of 1193.2 mm was received during crop season against normal rainfall of 995 mm in 2011. There was an excess rainfall of 74.7, 27.4 and 51.9% during June, August and September, respectively over normal rainfall of these months. However, 9.9 per cent deficit rainfall was received during July. Further, no rain was received in the months of October, November and December (Fig. 10).

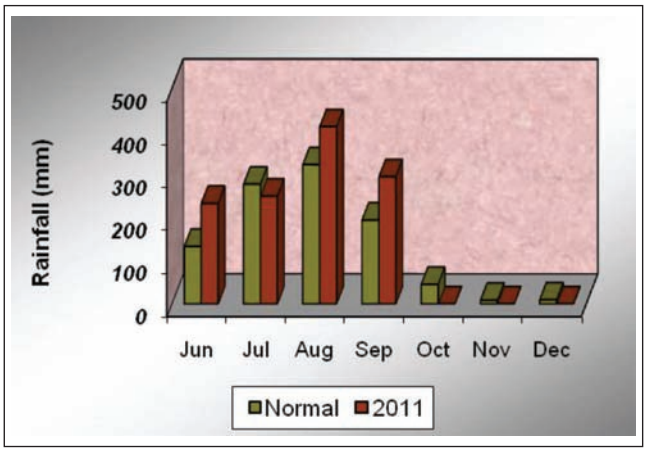

Fig. 10 : Normal and actual (2011) monthly rainfall at Faizabad

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Faizabad in Hardoiya village, block- Haringtonganj, tehsil-Milkipur in Faizabad district, Uttar Pradesh. The total cultivated area is 397 ha out of which 138 ha is rainfed. The mean annual rainfall is 1040.1 mm with seasonal rainfall of 967.5 mm during *kharif* (June-September). The major soil types are silty loam and silty clay. The major crops during *kharif* under rainfed are upland rice, maize, pigeonpea, blackgram, sorghum and pearlmillet and *rabi* are chickpea, lentil, mustard, linseed and barley. The numbers of land less, marginal, small and medium farmers are 55, 445 and 155, respectively. The ground water table is 6 metre. The source of irrigation is tube well and ponds covering 65% of cultivated area.

Climate Variability in General

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 90%, north-east monsoon 8% and summer 2% of the total annual average rainfall of 1041.1 mm. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 15-20 % *deficit* of the average rainfall. The onset (south-west) of monsoon is during 25 SMW. The dry spells during crop season are experienced (for the past 10/15 years) during September at grain setting and maturity stages of the major rainfed crops. The onset of the monsoon is shifting to 25 SMW and with early withdrawal i.e during 39 SMW. The soil moisture status is deficit during growth and flowering stages of major rainfed crops during *rabi*. The maximum/minimum temperature during *kharif* season 39.3 and 25.7°C and during *rabi* season it was recorded 44.5 and 5.1°C. The extreme events like unusual and high intensity rainfall in shortspan are decreasing during August and September during *kharif* and December and January during *rabi* seasons. The area is also experiencing other extreme events like hail storm, frost, heat wave and cold wave.

Experienced weather conditions during the year (2011-12)

The village received 1193.2 mm which was excess of 239.1 mm compared to normal 917.2 mm during south-west monsoon (*kharif*). The onset of monsoon was normal. The crops experienced dry spell during 21st August to 2nd September 2011. No intense rainfall events were experienced during crop growing season. These events impacted the stand/ performance of rice and maize crops adversely.

Interventions

The major interventions were implemented under on-farm demonstrations included crops and varieties. These interventions covered an area of 22 ha in 79 farmers' fields.

Crops/ Varieties

Under this component, the suitable varieties of rainfed crops upland rice NDR-97, Baranideep, Susksamrat and

Vandana, pigeonpea (NDA-1, NDA-2, Bahar and MA-6) during *kharif* and chickpea (Avarodhi, KWR-108, PG-186 and Pusa-362) during *rabi* were introduced to cope with the rainfall variability of the region. The yield increase and RWUE was up to 74.7% and 23.52 (kg/ha/mm) with improved varities (Fig. 11a, 11b) - (Table 21).

Table 21 : Performance of Improved varities of rainfed crops under normal onset of monsoon

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha/mm)	BC ratio
		Improved practice	Farmers' practice			
Upland rice	NDR 97	2015	1200	67.9	1.87	1.50
	Suskasamrat	1840		53.3	1.83	1.47
	Vandana	1975		64.6	1.78	1.44
	Baranideep	1930		60.8	1.70	1.37
Pigeonpea	NDA-1	1660	1000	66.0	2.87	4.24
	NDA-2	1695		69.5	2.93	4.33
	Bahar	1595		59.5	2.76	4.07
	MA-6	1300		30.0	2.25	3.32
Chickpea	Avarodhi	1520	950	60.0	23.52	3.02
	KWR-108	1370		44.2	21.20	2.72
	PG-186	1420		49.5	21.97	2.82
	Pusa-362	1660		74.7	25.72	3.30

Fig. 11a : Pigeonpea cv. NDA-2

Fig. 11b : Pigeonpea local variety

1.1.4. JAGDALPUR

a. Jagdalpur

Jagdalpur centre is located in Garjat hills, Dandakarannya and eastern ghats eco-sub-region (AESR 12.1) and Bastar plateau agroclimatic zone in Chattisgarh The climate is hot moist sub-humid. Annual normal rainfall is 1297 mm. The length of growing period is 180 – 210 days.

b. On-station experiments

At Jagdalpur, the onset of monsoon was during second fortnight of June. The actual rainfall received during cropping period of 2011 was 1115.6 mm as against normal of 1230.5 mm. August and September received an excess rainfall of 7.5 and 22.3%, respectively than normal rainfall. However, a deficit rainfall of 20.3, 7.5 and 86.7% was received during June, July and December months, respectively over normal (Fig. 12). Further, October and November no rain was received during in *kharif* growing period, average maximum temperature was 29.18^{0}C and average minimum temperature was registered 20.24^{0}C. Total number of rainy days was 36 during crop growing period.

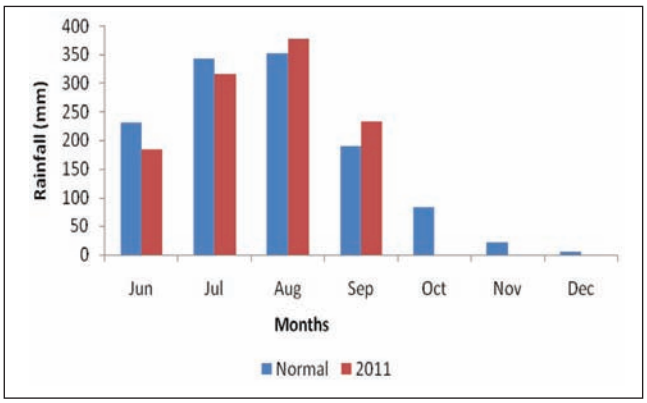

Fig. 12 : Normal and actual (2011) monthly rainfall at Jagdalpur

Efficient energy use and management

Paddy transplantor (Fig. 13) did not perform well as compared to manual transplanting with 10.74 energy output: input ratio and 15212.61 MJ/ha total energy (Table 22).

Fig. 13 : Transplanting of rice cv. Swarna with Paddy Transplantor

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Jagdalpur in Tahkapal, Tandpal and Gumiyapal villages in Tokapal in tehsil in Bastar district, Chhattisgarh. The total cultivated area is 511.25 ha out of which 500 ha is rainfed. The mean annual rainfall is 1399.1 mm with seasonal rainfall of 1118.7 mm during *kharif* (June-September). The major soil types are shallow, medirum to deep black mixed red and black soils. The major rainfed crops during *kharif* are rice, maize, minor millets and during *rabi* are vegetables, chikpea, kulthi and niger. The number of marginal, small, medium and large farmers are 61, 269, 86 and 20, respectively. The ground water table is 6 to 15 m depending upon topography and season. The source of irrigation is farm ponds and wells covering 2 % of cultivated area.

Table 22 : Efficient energy management with paddy transplanter

Implement	Crop/ Variety	Yield (kg/ha)	Total energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Paddy Transplantor	Swarna	3340	15212.6	163394.6	9910.4	38123	28212.6	2.84

Climate Variability in General

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 80 %, north-east monsoon 8.2 %, winter season 1.5% and summer 10.3 % of the total annual average rainfall of 1399.1 mm. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was by 14 % deficit of the average rainfall. The onset (south-west) of monsoon is during 24 SMW. The dry spells experienced for the past 32 years (5 dry spells in September and 11 dry spells in October) and at panicle initiation and reproductive stages of the rice. The normal onset of the monsoon was 12th June (24th SMW) and withdrawal was 25th September (39th SMW). The soil moisture status is deficit during panicle initiation and reproductive stages of major rainfed crops. During past 10 years the maximum temperature during *kharif* crop season was decreasing by 0.6^{0} C and by 0.4^{0} C during *rabi* season whereas minimum temperature during *kharif* crop season decreasing by 0.7^{0} C and by 1.8^{0} C during *rabi* season. The extreme events like unusual and high intensity rainfall in short span are increasing (30, 32 and 34 SMWs during July-August and 41 and 44 SMWs during October. The area has been also experiencing extreme events like hail storms, floods and cold waves (occasionally). There has been considerable shift in rainfall pattern and the quantum of rainfall during SW monsoon (6%) and N-E monsoon season (32%) has increased during last10 years and sowing window of the dominant rainfed crops delayed from 24th to 25th SMW.

Experienced weather conditions during the year (2011-12)

The village received rainfall of 1114.8 mm which was deficit by 3.9 mm compared to normal 1118.7 mm during south-west monsoon (*kharif*). The onset of monsoon was normal. The crops experienced dry spells during 39 SMW to 47 SMW (Fig. 14) coinciding with panicle initiation and flowering stages of the rice crop. The intense rainfall events were experienced on 29th August 2011 (79.6 mm of rainfall quantity during *kharif* crop growing season). There was complete cessation of rainfall after 26th September which caused in terminal drought for *kharif* crops and severely affected sowing of *rabi* crops.

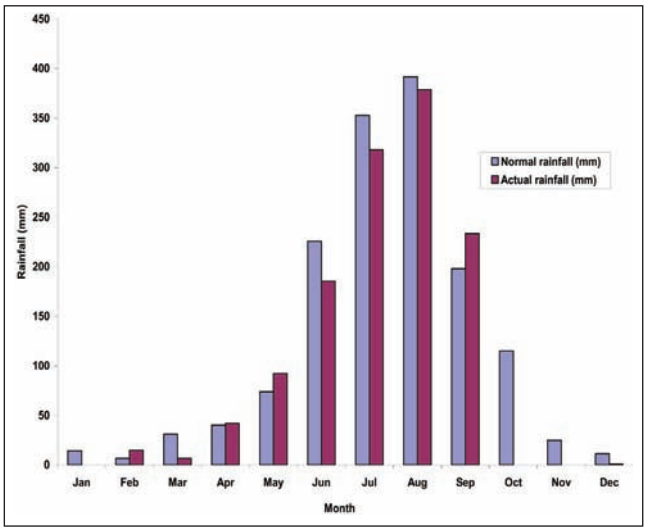

Fig. 14 : Normal and actual (2011) monthly rainfall at Tahkepal Village

Interventions

The major interventions included rainwater harvesting and recycling and timely operations through custom hiring center. These interventions covered an area of 7.61 ha in 26 farmer's fields.

Rainwater harvesting and recycling

A farm pond size (9.5x24x1.5 m^3) capacity 342 m^3 was dug for efficient rainwater harvesting and recycling. The two existing farm ponds in the village are of size of (30 x 30 x 2.5 m^3) and (27 x 24 x 2.5 m^3) and were renovated. The stored water in the farm ponds during *kharif* 2011 was efficiently utilized for supplementary irrigation/life saving irrigation of 10 to 14 cm during various stages of the vegetable crops (Fig. 15) (Table 23 & 24).

Fig. 15 : Vegetable cultivation using harvested rain water

Vegetable production with harvested rain water as supplemental irrigation

a. Lakshman/Ramu field in Tahakapal Village

Table 23 : Efficient utilization of harvested rainwater

Crop	Variety	Yield (kg/ha) Supplementary irrigation/ Life saving irrigation	Net returns (Rs/ha)	BC ratio
Tomato	Pusa ruby	12000	96011	4.00
Cauliflower	Pusa JL-80	6000	145911	4.28
Cabbage	Pride of India	6500	95911	2.89
Chilli	Japani laungi	7500	200781	8.29
Brinjal	Green long	8500	144311	5.62

b. Ramprasad/Shyamsundar field in Gumiapal Village

Table 24 : Efficient utilization of harvested rainwater

Crop	Variety	Yield (kg/ha) Supplementary irrigation/ Life saving irrigation	Net returns (Rs/ha)	BC ratio
Tomato	Pusa ruby	11550	91511	3.81
Cauliflower	Pusa JL-80	6220	152511	4.47
Cabbage	Pride of India	6320	92311	2.71
Chilli	Japani laungi	7730	207681	8.58
Brinjal	Green long	8480	143911	5.60

Energy management

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements Mahakal seed drill, Bhoram dev seed drill and Automatic seed drill were made available. Use of improved seed drills resulted in high net returns (Fig. 16) (Table 25).

Table 25 : Performance of improved seed drills in fingermillet

Implement	Crop	Variety	Energy (MJ/ha) for improved implement		Net returns (Rs/ha)	BC ratio
			Input	Output		
Mahakal seed drill	Fingermillet	GPU-28	5502.72	51875	21747.34	5.57
Bhoramdev seed drill			5482.52	48684	19256.52	4.97
Automatic seed drill			5482.52	43920	16517.13	4.04

Fig. 16 : Demonstration of improved seed drills

1.1.5 PHULBANI

a. Agro-ecological setting

Phulbani center is located in Eastern Plateau (Chotanagpur) and Eastern Ghats, Garjat Hills, Dandakarannya and Eastern Ghats (AESR 12.1), and Eastern ghat agroclimatic zone in Odisha. The climate is hot moist sub-humid. Annual normal rainfall is 1378 mm. Annual normal potential evapo-transpiration is 478 mm. Length of growing period is 180-210 days.

b. On-station experiments

At Phulbani, the onset of monsoon was on 23rd June i.e. delayed by 10 days as compared to normal onset. A rainfall of 1123 mm was received during cropping period of 2011 as against normal of 1245.8 mm. June and September months received an excess rainfall of 22.4 and 65.3 per cent, respectively as against the normal. However, months like July, August and October months received a deficit rainfall of 61.2, 15 and 11.6%, respectively over normal (Fig 17). Further, both November and December months did not receive any rainfall.

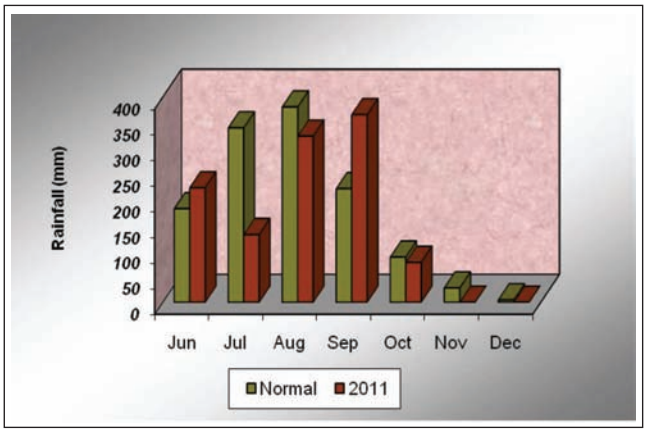

Fig. 17 : Normal and actual (2011) monthly rainfall at Phulbhani

Real time contingency crop planning

Eight contingency crops *viz*. radish, maize, cowpea, pea, greengram, blackgram, horsegram and niger were evaluated. The crops were sown on 21st August, 2011. Except pea, which failed due to poor germination, all other crops germinated well but suffered from soil moisture stress. However, the improved varieties of radish (1205 kg/ha), cowpea (423 kg/ha), greengram (41 kg/ha), blackgram (33 kg/ha), horsegram (51 kg/ha), maize (203 kg/ha) and niger (37 kg/ha) gave average yields (Table 26).

Table 26 : Performance of contengency crops under delayed onset of monsoon.

Contingent crop	Yield (kg/ha)	Remarks
Radish (Pusa Chetki)	1205	Good
Maize (Nirmal 51)	203	Average
Cowpea (Gomti)	423	Good
Pea	-	Failed
Greengram (Samrat)	41	Good
Blackgram (T9)	33	Good
Horsegram (Local)	51	Good
Niger (Local)	37	Average

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre Phulbani in Budhadani village, Phulbani tehsil in Kandhamal district, Odisha. The total cultivated area is 101. 21 ha out of which 81.96 ha is rainfed. The mean annual rainfall is 1123 mm with seasonal rainfall of 1045 mm during *kharif* (June-September). The major soil types are red lateritic and brown forest soils. The major rainfed crops during *kharif* are rice, maize, turmeric and during *rabi* are greengram, blackgram and vegetables. The number of small, marginal, medium and large farmers is 29.26%, 51.63%, 19.11%, respectively. The ground water table is 5 m.

Climate Variability in General

The climate in this agro-climatic zone is sub-humid. Out of the total annual average rainfall of 1407 mm, south-west monsoon contributes 80 %, north-east monsoon 10% and summer rainfall 10%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 7.2% surplus of the average rainfall. The onset (south-west) of monsoon was during 24 SMW. For the past 15 years, the dry spells during crop season had been experienced at germination to reproductive stages in various rainfed crops. The onset of the monsoon is erratic. The extreme events like unusual and high intensity rainfall in short span are increasing during *kharif* and *rabi* seasons.

Experienced weather conditions during the year (2011-12)

The village received 1119 mm which was deficit of 127.2 mm compared to normal (1246.2 mm) during south-west monsoon (*kharif*). The onset of monsoon was early. The crops experienced dry spells during germination, tillering and maturity during 26 SMW (25 June – 1 July), 28 SMW (9-15 July), 30 SMW (23-29 July), 37 SMW (10-16 September), 39-41 SMW (24 September-14 October) stages (Fig. 18). The intense rainfall events were experienced on 12 August 2011 (74 mm), 24 August 2011 (52 mm), 22 October 2011 (54 mm). These events impacted the stand and performance of greengram, groundnut crops adversely.

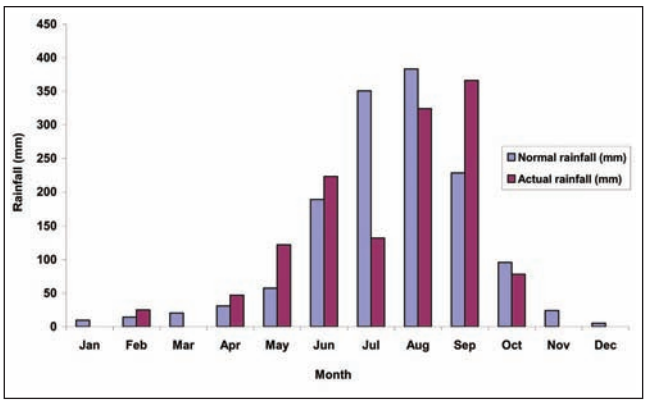

Fig. 18 : Normal and actual (2011) monthly rainfall at Budhadani Village

Interventions

The major interventions were implemented both under on-farm include crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 17 ha in 101 farmers' fields.

Crops/ Varieties/Cropping system

The improved varieties of rice (Vandana, Khandagiri) (Fig. 19a, 19b), maize (Nirmel 51) and cowpea (Gomti) in maize + cowpea (2:2) inter cropping system (Fig. 20a, 20b) were introduced to cope with the rainfall variability of the region (Table 27 & 28).

Table 27 : Performance of improved varieties of rice

Variety	Yield (kg/ha)		BC ratio
	Improved practice	Farmers' practice	
Vandana	2034	1500	1.46
Khandgiri	2338	1500	1.80
Jhalka -Local	-	1500	

Table 28 : Performance of maize + cowpea (2:2) intercropping system

Crop	Variety	Maize equivalent yield (kg/ha)		BC ratio
		Improved practice	Farmers' practice	
Maize + cowpea (2:2) intercropping system	Maize (Nirmal) Cowpea (Gomti)	5430	-	2.56
Sole maize		-	1950	

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was also constituted. The improved implements power tillers, M.B plough, reaper etc were made available for various operations in rice and maize.

Fig. 19a : Improved practice- Rice cv. Sahabhagi

Fig. 19b : Farmer's practice - Local rice

Fig. 20a : Maize + cowpea (2:2) intercropping system

Fig. 20b : Sole maize

1.1.6 VARANASI

a. Agro-ecological setting

Varanasi center is located in Northern Plain, Rohilkhand, Avadh and south Bihar Plains (AESR 9.2) and Eastern plateau and vindhyan zone in Uttar Pradesh. The climate is hot dry sub-humid. Annual normal potential evapo-transpiration is 577 mm. Annual normal rainfall is 1078 mm. Length of growing period is 150-180 days. Drought occurs once in six years.

b. On-station experiments

At Varanasi, the onset of monsoon was on 16th June i.e. four days early than normal onset. It withdrew on 26th September. A rainfall of 1195 mm was received during cropping period of 2011 as against normal of 1005.4 mm. June and September months received an excess rainfall of 203.3 and 92%, respectively as against the normal. Further, months like July, August, October, November and December received a deficit rainfall of 32.8, 12.7, 92.7, 100 and 100 per cent over normal, respectively (Fig. 21). There were three dry spells during July and August months.

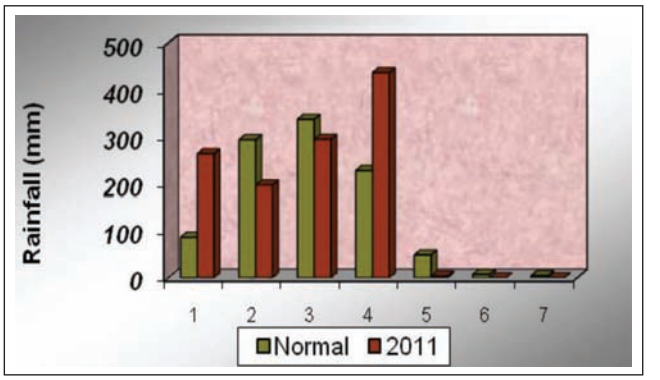

Fig. 21 : Normal and actual (2011) monthly rainfall at Varanasi

During *kharif* 2011, custard apple and guava based agri-horti systems were demonstrated at South campus farm (BHU), Mirzapur (Fig. 22 & 23). The arable crops viz., pearlmillet, greengram and sesame were harvested during last week of September to first forthnight of

Table 29 : Yield and economics of Custard apple and Guava based agri-horti system

System	Yield (kg/ha)		Cost of cultivation (Rs/ha)			Gross returns	Net returns	BC Ratio
	Fruit	Crop	Fruit	Crop	Total			
Custard apple based								
Custardapple + greengram	2810	380	9000	6800	15800	79750	63950	4.0
Custardapple + sesame	2750	180	9000	7200	16200	25050	58850	3.6
Custardapple + pearlmillet	2790	1200	9000	9800	18800	87750	68950	3.66
Guava based								
Guava + greengram	350	350	4200	6800	11000	78750	67750	6.0
Guava + sesame	3600	150	4200	7200	11400	77250	60850	5.3
Guava + pearlmillet	3100	1100	4200	9800	14000	78500	64500	4.6
Greengram		480	-	6800	6800	12000	5200	0.76
Sesame		208	-	7200	7200	7200	-	-
Pearlmillet		1280	-	9800	9800	19200	9400	0.95

Custard apple Rs 25/kg, Guava – Rs 20/kg, Greengram – Rs 40/kg, Sesame – Rs 35/kg, Pearlmillet – Rs 8/kg.
Initial lost of orchard establishment (Rs/ha) – Guava – 7000 & Custard apple – 6000 (pw/ha)
Current rate of maintenance of orchard – Rs 15/Plant

Fig. 22 : Custard apple based agri-horti system

Fig. 23 : Guava based agri-horti system

October. In custardapple based system, custardapple + greengram gave higher net returns (Rs. 63,950/ha) and BC ratio (4.0). Similarly, in guava based system, guava + greengram gave higher net returns (Rs. 67,750/ha) and BC ratio (6.0) (Table 29).

c. On-farm experiments

Village profile

The program is implemented in Terha Saraya Village, Mirzapur Dist., Uttar Pradesh by AICRPDA centre, Varanasi, Uttar Pradesh. The total cultivated area is 290 ha out of which 210 ha is rainfed. The mean annual rainfall was 1191 mm with seasonal rainfall of 948 mm during *kharif* (June-September). The major soil types are sandy loam and loamy sand. The major rainfed crops during *kharif* are rice, maize, pearlmillet, greengram, pigeonpea and during *rabi* are wheat, chickpea, sesame, pea and linseed. The number of small, marginal, medium and large farmers are 0, 45, 85, 120 respectively. The ground water table is 10 (LL) cm. The irrigated area is 15-25% of cultivated area.

Climate Variability in General

The climate in this agro-climatic zone is semi-arid to sub-humid. Out of the total annual average rainfall of 1191 mm, the south-west monsoon contributes 80%, north-east monsoon 15 % and summer rainfall 5%. Mirzapur district of Uttar Pradesh experiences intra-seasonal variability of rainfall (intermittent dry spells in standing crop), extreme events (flash floods, heat wave and cold wave) and unseasonal rains. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 25 to 50 % deficit of the average rainfall. The onset (south-west) of monsoon was during 26 SMW. For the last 15 years, the dry spells during crop season were experienced in July, August and September and at flowering and grain filling stages of the major rainfed rice. The onset of the monsoon had been early (June 16, 2011) compared to the normal. The extreme events like unusual and high intensity rainfall in short span had been increasing during *kharif* and *rabi* seasons.

Experienced weather conditions during the year (2011-12)

During 2011-12, the village received 243 mm excess rainfall (1191 mm) compared to normal (948 mm) during South-west monsoon. Early onset of monsoon (June 16) associated with strong current, dry spells of one week (July 30 – August) and 2 weeks (August 20 – September 2),4 intense rainfall events (July 22, August 12 & 14 and September 16) and heavy single day rain storm (272.8 mm on September 25) were specific features of monsoon encountered during the season. The heavy rain storm during 2nd fortnight of July, 1st fortnight of August and 1st week of September impacted the stand of pulses and oilseed crops adversely. Further, single rainstorm of September 25th floaded rice fields (Fig. 24) and caused severe damage to pulses and oilseed crops while supplementing to hydraulic load to other systems.

Fig. 24 : An intense rain storm on 25 September (272.8 mm) flooded the fields

Interventions

Under NICRA, the technology demonstrations were taken up both under on-farm and on-station. The package included crops/varieties, cropping system, land configuration, runoff collection, drainage and alternate land use. These interventions covered in 27 ha in 69 farmers' fields.

Land configuration

Physiography of the village area is gentle sloping with average slope of 1 to 4 percent having rolling to undulating topography. Relief ranges from convex to concave forming major land forms in uplands, mid lands and low lands.

Surface relief provides high to moderate flow of surface water except at places stagnating water causing drainage problems. Change in land configuration, i.e. from flat planting to ridge furrow method of planting facilitated runoff modulation, enhanced *in-situ* moisture conservation and improved the drainage. The improved varieties of pigeonpea faired well on ridge with higher net returns and cost-benefit ratio compared to broad-casting (Fig. 25) (Table 30).

Fig. 25 : Ridge furrow planting of rice and pigeonpea

Crops/Varieties/Cropping system

Under this component, suitable varieties of rainfed rice (NDR-97, NDR-105, HUR-3022), maize (Shweta, Local), pigeonpea (Bahar, NDA-1, Chamatkar), (Table 31) sesame (GT-1, Shekhar, Local) during *kharif* and chickpea (RAC-888), lentil (HUL-57), fieldpea (M-15, Local), mustard (Varuna T-59, Local) linseed (Garima, Local) during *rabi* were introduced to cope with the rainfall variability of the region. NDR-97, NDR-105 varieties of rice gave higher yield even during excess rainfall event (Fig. 26).

Fig. 26 : Performance of NDR-97 under heavy rainfall conditions

Table 30 : Performance of rice (furrow) and pigeonpea (ridge) intercropping system

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	BC ratio
		Improved practice	Farmers' practice			
Rice	NDR 97					
Pigeonpea	Bahar	1922	1070			
	REY	8866	3500		9.85	1.47

Table 31 : Performance of improved varieties of *kharif* rainfed crops

Crop	Variety	Yield (kg/ha)		% increase in yield
		Improved practice	Farmers' practice	
Pigeonpea	Bahar/NAI	2000	1000	100
Greengram	HUR-12/16	800	500	60.0
Pearlmillet		3500	1500	133.0
Rice	NDR-97	2500	1500	66.6
Maize	Pragati	2570	1600	
Pearlmillet	BK-560	1850	400	
Greengram	HUM-16	760	125	

Rainwater harvesting and recycling

The Village Climate Risk Management Committee (VCRMC) decided to improve the drainage conditions and collecting surplus water in appropriate structures for supplementary irrigation. A farm pond size of 60.5 x 42 x 5 m capacity 12705 m^3 was dug for efficient rainwater harvesting and recycling. The existing farm pond in the village is of size 80 x 69 x 2.25 m was renovated (Fig. 27). The stored water in the farm pond during this year was efficiently utilized for supplementary irrigation of 5 cm during critical stages of the crop.

Fig. 27 : Farm pond in Terha Saraya Village

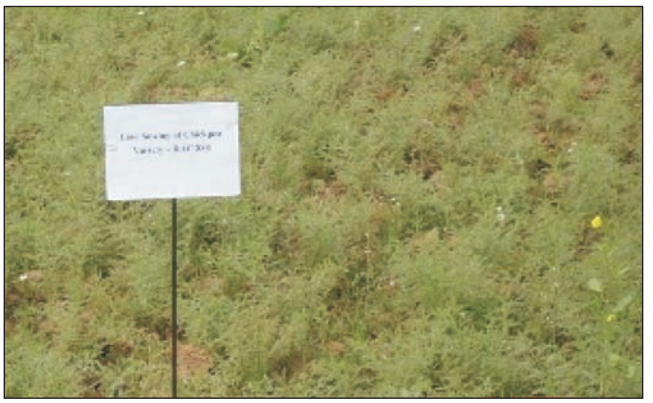

Fig. 28a : Chickpea RAC-888

Fig. 28b : Chickpea Local

The more rainfall received during the year helped in maximum hydraulic load capacity. Supplementary irrigation was provided using this harvested water which helped in enhancing the yield, monetary returns of wheat, chickpea, and mustard. (Fig. 28) (Table 32).

Timely operation through Custom Hiring Centers

A custom hiring center was established in the village with need based implements and a custom hiring committee was constituted to run the activities smoothly. The improved implements like ridger seeder, harrow, thresher gave higher output energy and seed yield compared to normal implements. Energy input and output for different crops and cropping system was influenced by using the improved mechanical units. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period (Table 33).

Table 32 : Performance of rabi crops with supplemental irrigation from the harvested rainwater

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net returns (Rs/ha)	BC ration
		Supplementary irrigation/ Life saving irrigation	Without irrigation			
Wheat	HUL 533	1475	1235	19.4	12785	1.94
Chickpea	RAC 88	1625	1380	17.7	35470	3.63
Mustard	T-59	940	730	28.7	17269	2.37

Table 33 : Energy management with improved implements in upland rice

Implement	Crop	Variety	Energy (MJ) for improved implement		Energy (MJ) for normal implement		Net returns (Rs/ha)	BC ratio
			Input	Output	Input	Output		
M.B.Plough	Rice	NDR-97	10791	95427	241	48450	189701.14	1.30
Seed drill	Rice	NDR-97	565	95427	62.72	52420	15183.85	1.04

Alternate land use and Eco-system services

Custard apple based and guava based agri- horti system with greengram, sesame, pearlmillet crops were demonstrated in farmers' fields (Fig. 29). Agro forestry, agro-horti and other carbon capture systems help in both adaption mitigation. Hence these intervene-tions were made to educate farmers that climate change need to be tackled both short term and long term strategies. These interventions helped the farmers in the village during this excess rainfall year and farmers realized significantly higher yields by minimizing water logging problem. These systems are gradually attracting farmers' attention and more and more farmers are getting attracted to adopt such interventions to cope with climate variability in the region.

Fig. 29 : Guava based agro-horti system

1.2. Maize Based Production System

1.2.1 ARJIA

a. Agro-ecological setting

Arjia is located in north Gujarat plain (inclusion of Aravalli range and east Rajasthan Uplands) hot dry semi-arid eco-sub region (AESR 4.2) and Southern zone in Rajasthan. Normal annual rainfall is 658 mm. Annual potential evapo-transpiration is 1681 mm. Length of growing period is 90-120 days.

b. On-station experiments

At Arjia, a total of 722.0 mm of rainfall was received during the year 2011 against the normal annual rainfall of 634.7 mm (Fig 30). During the year 2011, 10 mm pre-monsoon rainfall was received. The effective onset of monsoon was on 25th June, which was earlier than normal onset of monsoon by 7 days. The seasonal distribution of rainfall indicates that the rainfall received during the monsoon season was 718.0 mm, which contributed to 99.4% of total annual rainfall. The numbers of rainy days were 37 in 2011 as compared to normal value of 33. Further, during post monsoon season no rain was received against normal rainfall of 16.4 mm. This resulted in decrease of area under *rabi* crops and enhanced the crop water requirements.

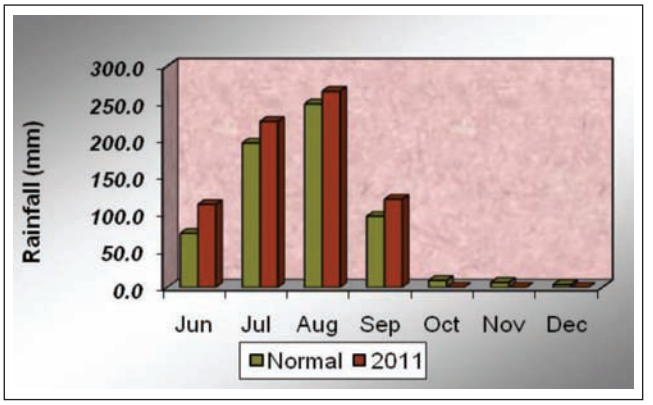

Fig. 30 : Normal and actual (2011) monthly rainfall at Arjia

The early withdrawal of south-west monsoon by 14 days affected the crop yield. During this season, October received no rainfall against normal rainfall of 9.6 mm. However, during this year, no winter rainfall was received against the normal value of 11.7 mm rainfall, which had negative effect on area and yield of rabi crops in the region. Further, a terminal dry spell occurred from 17th September onwards which resulted in severe reduction of crop yield most of the long duration crops were at grain formation stage.

Real time contingency crop planning

Different varieties and intercropping systems were evaluated under real time rainfall situation. There was not a single drought week observed during this year which results in good yields of maize and groundnut whereas pulses and sesame were affected due to excessive rainfall. The maize equivalent yield (MEY) revealed that groundnut gave highest MEY (4774 kg/ha) and was 13% higher over sole maize PM-3 (4213 kg/ha). Maize variety EC-3161 (4690 kg/ha) performed well compared to maize variety PM-3. Under one week early onset of monsoon, groundnut crop found to be better than maize crop in this region (Table 34).

Table 34 : Performance of *kharif* crops and cropping systems under early onset of monsoon situation

Treatments	Fodder yield / plot (kg)	Seed yield/ plot (kg)	MEY (kg/ha)
Sole maize	32.0	18.20	4213
Maize + blackgram (2:2)	-	-	3149
Blackgram sole	13.0	2.50	1591
Groundnut sole	-	7.50	4774
Groundnut + sesame	-	-	2614
Sesame sole	-	2.13	2054
Sorghum 67.0	18.0	3333	
Maize (EC 3161)	-	20.26	4690
Maize (Vivek)	22.50	18.60	4306

Different varieties and intercropping system were evaluated under real rainfall situation under late sown condition. The maize equivalent yield revealed that groundnut gave highest MEY (4264 kg/ha) and was 17.7% higher over sole maize PM-3 (3623 kg/ha). Under late sown condition, horsegram varities viz. AK-21 (1389 kg/ha) and AK-42 (1319 kg/ha) performed well with least care (Table 35).

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

A study on runoff, storage and recycling was conducted during the year 2011 at Dryland Farming Research Station, Arjia. During the year 2011, rainfall recorded was 722 mm out of which 722 mm (100%) was recorded during rainy season and no rainfall recorded during post-monsoon season. The rainfall-runoff study indicated that the highest runoff (565.58 m^3) was recorded during the month of August, which was 52.4% of total runoff during the year. However, average runoff was recorded as 41.3% of total runoff producing rainfall (498.4 mm). The runoff producing rainfall was 498 mm which contributed to 69.0% of the annual rainfall during this year (Table 36).

The harvested rainwater was efficiently utilized for supplimental irrigation to vegetable crops and maize.

Table 35 : Performance of crops and cropping systems under late sown situation during *kharif*.

Treatments	Days to tasseling	Silking/ flowe-ring	Days to matu-rity	Plant height (cm)	100/ 1000 seed (g)	Fodder yield/ plot (kg)	Seed yield/ plot (kg)	MEY (kg/ ha)	% increase over maize
Sole maize	40	44	74	250.0	20.40	21.50	15.65	3623	-
Maize+ blackgram	-	-	-	-	-	-	-	3711	2.43
Maize	39	43	74	25.5	21.59	18.00	11.35	--	-
Blackgram	-	40	72	68.4	4.50	14.00	3.50	2228	-
Groundnut sole	-	24	89	54.0	27.67	14.00	6.7	4264	17.69
Groundnut + sesame	-	-	-	-	-	-	-	4023	11.04
Groundnut	-	23	87	57.4	28.56	9.00	4.50	-	-
Sesame	-	28	78	132.0	2.72	-	1.20	-	-
Sesame sole	-	29	79	136.4	2.70	-	2.50	2412	-
Sorghum	-	57	95	195.0	3.00	46.0	12.90	2389	-
Horsegram (AK-21)	-	78	107	81.0	3.32	21.0	6.00	2546	-
Horsegram (AK-42)	-	73	102	62.2	3.63	20.0	5.7	2419	-

Table 36 :Runoff from the small agricultural watershed during the year 2011

Month	Rainfall (mm)		Runoff (m^3)	% runoff of monthly rainfall	% runoff producing rainfall
	Monthly	Runoff producing rainfall			
June	112	68	111.52	4.86	8
July	225	147	227.61	4.93	7.55
August	266	218.4	565.58	10.37	12.63
September	119	65	174.25	7.14	13.08
October	0	0	0	0.00	0
November	0	0	0	0.00	0
December	0	0	0	0.00	0
Total	722	498.4	1078.96	27.3	41.26

Kachari recorded the highest maize grain equivalent yield of 9017 kg/ha with a BC ratio of 6.53 and water productivity of 6.43 kg/m^3. Maize recorded 43 kg/ha grain yield with the application of one irrigation (5 cm) during dry spell period with BC ratio of 3.77. Water saving in the Kachari was to the tune of 41.44% as compared to bottle gourd. Drip irrigation was saved the water by 48.2 percent with the increased maize grain equivalent yield of 18%. Further, highest water productivity (6.46 kg/m^3) was recorded in Kachari while it was 2.92 in ridgegourd. The Kachari recorded highest net return with saving of water by 41.44 as compared to bottle gourd. In case of drip irrigation, irrigated area of Kachari may be increased to 48% in comparison to surface method of irrigation in cucurbits (Table 37).

During *rabi* supplemental irrigation was given to vegetables viz Coriander (green) pea (pod) and bringal. Coriander recorded the highest pea pod equivalent yield of 70.83 q/ha with highest BC ratio and water saving by 8.8% over brinjal. The highest water productivity was recorded in the coriander green. Drip irrigation was saved the water by 46.1% with increased pea pod equivalent yield of 15.1% over surface method of irrigation (Table 38).

Efficient use of harvested rain water in different crops and cropping systems

- Maize + blackgram (2:2) and groundnut + sesame (2:2) cropping systems were found to be suitable for this region.
- One irrigation for maize + blackgram (2:2) recorded higher net returns (Rs. 24709/ha) and BC ratio (3.5) as compared to no irrigation and two irrigations. Further, for groundnut + sesame (2:2) cropping system two irrigations recorded higher net returns (Rs. 18750/ha) and BC ratio (2.82) as compared to no irrigation and one irrigations (Table 39).

Table 37 : Productivity and economics of *kharif* crops with supplemental irrigation from the harvested rainwater

Crop	Maize grain equivalent yield (q/ha)		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio	Water use (m^3/ha)	Water productivity (kg/ m^3)
	Grain	Stover						
Sponge gourd	77.67	-	21110	93200	72090	4.42	2769.17 (0.2)	3.20
Bottle gourd	81.25	-	20512	97500	76989	4.75	2773.33 (-)	3.32
Ridge gourd	70.97	-	22310	85167	69690	3.82	2755.00 (.7)	2.92
Kachari	90.17	-	16559	108200	91641	6.53	1624.17 (41.1)	6.46
Vegetable cowpea	62.67	35.33	19749	75200	55451	3.81	1665.83 (39.9)	4.33
Surface irrigation	70.21	34.00	19938	84253	67048	4.33	3052.67 (-)	2.45
Drip irrigation	82.88	36.67	20158	99453	79296	5.01	1582.33 (48.2)	5.64
Maize (irrigated) 5 cm	43.33	50.56	16592	62617	46025	3.77	810.00	5.35
Maize unirrigated	25.34	44.00	12075	39648	27573	3.28	0.00	0.00

Note : Figures in parenthesis indicates the percent water saving

Table 38 : Productivity and economics of *rabi* crops with supplemental irrigation from the harvested rainwater with different irrigation methods (2011-12)

Crops	Pea pod equivalent yield (q/ha)		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio	Water use (m^3/ha)	Water productivity (kg/ m^3)
	Pod	Stover						
Coriander (green)	70.83	-	21533	141667	120134	6.68	5014.17 (8.8)	1.58
Pea (pod)	54.17	26.93	19911	113988	94076	5.77	3988.33 (27.5)	1.50
Brinjal	37.33	-	22758	74667	51908	3.36	5497.50 (-)	0.78
Surface lrrigation	50.00	28.58	23336	102001	78665	4.43	6282.78 (-)	0.82
Drip lrrigation	58.22	25.27	19466	118213	98747	6.11	3383.89 (46.1)	1.75

Note : Figures in parenthesis indicates the percent water saving

Table 39 : Efficient utilization of harvested rainwater

Treatment	Maize equivalent yield (kg/ha)		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
	Grain	Stover				
Maize (sole)						
$Irri_0$	1542	4986	7600	25389	17789	3.34
$Irri_1$	1583	6194	7600	28222	20622	3.71
$Irri_2$	1539	5128	7600	25645	18045	3.37
M+BG(2:2)						
M+BG(2:2) $Irri_0$	2153	4844	9875	31217	21342	3.16
M+BG(2:2) $Irri_1$	2361	5486	9875	34584	24709	3.50
M+BG(2:2) $Irri_2$	2278	4147	9875	31072	21197	3.15
Blackgram						
$Irri_0$	1833	3906	5950	26145	20195	4.39
$Irri_1$	1667	3694	5950	24056	18106	4.04
$Irri_2$	2000	2692	5950	25384	19434	4.27
Sesame						
$Irri_0$	917	243	6020	9653	3633	1.60
$Irri_1$	993	205	6020	10340	4320	1.72
$Irri_2$	1069	299	6020	11292	5272	1.88
Groundnut						
$Irri_0$	2175	3061	9700	27872	18172	2.87
$Irri_1$	2014	2903	9700	25945	16245	2.67
$Irri_2$	1611	2639	9700	21389	11689	2.21
G +S (2:2)						
G +S (2:2) $Irri_0$	2646	2052	10300	30563	20263	2.97
G +S (2:2) $Irri_1$	2042	3034	10300	26486	16186	2.57
G +S (2:2) $Irri_2$	2516	1947	10300	29050	18750	2.82

i_0 – no irrigation, i_1 – one irrigation, i_2 – two irrigation, M-maize, BG- blackgram, G-groundnut

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Arjia in Kochariya village, Suwana block, Bhilwara Tehsil, district and in Lapsiya village, Railmagra block and Rajsamand district, Rajasthan. The total cultivated area is 287 ha and 253 ha out of which 220 ha and 197 ha are rainfed at Kochariya and Lapsiya villages, respectively. The mean annual rainfall was 657.7 mm and 512.9 mm with seasonal rainfall of 603 mm and 474 mm during *kharif* (June-September) at Kochariya and Lapsiya villages, respectively. The major soil types are sandy loam and sandy clay loam at Kochariya and sandy loam at Lapsiya village. The major rainfed crops during *kharif* are maize, blackgram, groundnut at Kochariya while sorghum, maize, blackgram at Lapsiya and during *rabi* are wheat, barley and mustard in both the villages. The ground water table is 210 m and 250 m at Kochariya and Lapsiya, respectively. The source of irrigation is dug well and tube well covering 23.9 and 22.13 % of cultivated area at village Kochariya and Lapsiya, respectively.

Climate Variability in General

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 657.7 mm, the south-west monsoon contributes 93.1%, north-east monsoon 3.7% and summer 3.2%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 17.8% *deficit* of the average rainfall. The onset (south-west) of monsoon was during 26 SMW. The dry spells during crop season were experienced, for the past 15 years had been during September and at reproductive stages of the major rainfed crops. The soil moisture status was deficit during reproductive stages of major rainfed crops. The maximum and minimum temperature during *kharif* crop growing season revealed an increase of 1.17°C in maximum temperature and decrease of 0.79°C as compared to their respective normal for the past 20 years. During *rabi,* there was a decrease of 0.96°C in maximum temperature as compared to normal for the past 20 years**.** The extreme events like unusual and high intensity rainfall in short span were increasing during August during *kharif*. The area had been experiencing drought during *kharif* and frost during *rabi*. There had been considerable shift in rainfall pattern which resulted to change in climate from *dry sub humid to semi arid and sowing* window had been shifted by almost one week to 25 SMW for the dominant rainfed crops.

Experienced weather conditions during the year (2011-12)

At Kochariya village, an amount of 540.5 mm was received during south-west monsoon (*kharif*). which was a *deficit of* 117.2 mm compared to normal (657.7 mm) (Fig 31). The intense rainfall events were not experienced *for kharif and rabi*. At Lapsiya village, an amount of 462.2 mm was received during south-west monsoon (*kharif*)

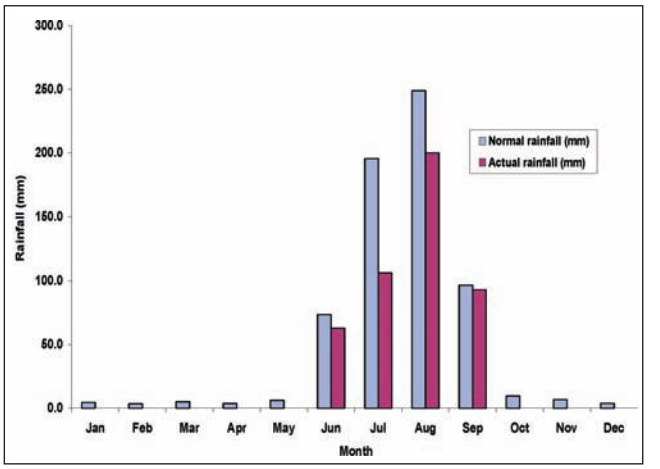

Fig. 31 : Normal and actual (2011) monthly rainfall at Kochariya Village

which was a deficit of 50.7 mm compared to normal (512.9 mm). In both the villages, the onset of monsoon was normal and the crops experienced dry spells during third week of September onwards and at reproductive stages.

Interventions

The major interventions were implemented include land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 50.5 ha in 200 farmers' fields.

Land configuration

The land configuration included ridge furrow system and peripheral bunding which facilitated runoff modulation and enhanced *in-situ* moisture conservation which helped the maize crop to overcome dry spell and resulted in yield enhancement by 21.21 % and rainwater use efficiency by 19.6% compared to farmers practice of flat bed (Fig. 32a, 32b) (Table 40).

Table 40 : Performance of maize (PM3) with ridge and furrow system

Crop	Village	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha/mm)	BC ratio
			Improved practice (ridge furrow system and peripheral bunding)	Farmers' practice (Flat bed)			
Maize	Kochriya	PM3	2840	2343	21.21	6.29	3.60
	Lapsiya	PM3	2384	2061	15.67	5.83	3.07

Fig. 32a : Maize with ridge and furrow system

Fig. 32b : Maize with flat bed system

Crops/ Varieties/Cropping system

The drought tolerant varieties of maize (PM3), sorghum (Pratap-1430), blackgram (TAU-2), groundnut (TG-37A) during *kharif* and wheat (Raj 3765) during *rabi* were introduced to cope with the rainfall variability of the region (Fig. 33a, b, c, d & e). To minimize the risk of crop failure, to enhance the productivity of cropping system per unit of rainwater and to mitigate the dry spell during reproductive stage of major rainfed crops, intercropping systems viz.; maize + blackgram (2:2), groundnut +

Table 41 : Performance of drought tolerant varieties of rainfed crops under mid season drought situation at Kochriya

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved Practice	Farmers' practice (Local variety)		
Maize	PM-3	2550	2017	26.42	3.13
Sorghum	Pratap-1430	2628	1804	45.67	4.77
Blackgram	TAU-2	563	287	96.16	3.63
Groundnut	TG-37A	2400	2025	18.5	5.26
Wheat	Raj 3765	4878	3972	22.8	2.36

Table 42 : Performance of drought tolerant varieties of rainfed crops under mid season drought situation at Lapsiya

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved practice	Farmers' practice		
Maize	PM-3	2380	1908	24.73	2.92
Sorghum	Pratap-1430	2676	1814	47.51	4.83
Blackgram	TAU-2	623	443	40.63	4.01
Groundnut	TG-37A	2267	1517	49.43	4.98
Wheat	Raj 3765	4998	4140	20.72	2.4

sesame (6:2), sorghum + greengram (2:1) and blackgram + sesame (2:2) were evaluated (Fig. 34a, b, c, d & e). The yield (maize equivalent) increased with the improved varities was upto 96.1% at Kochariya and 49.43% at Lapsiya (Table 41 & 42) and with intercropping systems was upto 39.9% in both the villages (Table 43 & 44).

Fig. 33a : Maize - PM-3

Fig. 33b : Sorghum - Pratap-1430

Fig. 33c: Groundnut - TG-37A

Fig. 33d : Blackgram - TAU-2

Fig. 33e : Wheat - Raj 3765

Table 43 : Performance of intercropping systems at Kochriya

Crop	Maize Equivalent Yield (kg/ha)		% increase in yield	BC ratio
	Improved practice	Farmers' practice		
Maize+ black gram (2:2)	3073	2613	17.6	3.38
Sorghum+ green gram (2:1)	2700	1995	35.3	4.74
Groundnut + sesame (6:2)	1623	1198	35.4	4.03
Black gram + sesame (2:2)	589	421	39.9	3.17

Table 44 : Performance of intercropping systems at Lapsiya

Crop	Yield (kg/ha)		% increase in yield	BC ratio
	Improved practice	Farmers' practice		
Maize+ black gram (2:2)	2910	2493	16.73	3.22
Groundnut + sesame (6:2)	1441	1137	26.74	3.60
Black gram+ sesame (2:2)	589	421	39.9	3.17

Fig. 34a : Maize + blackgram intercropping (2:2)

Fig. 34b : Groundnut + sesame intercropping (6:2)

Fig. 34c : Groundnut + sesame mixed cropping

Fig. 34d : Sorghum + greengram intercropping (2:1)

Fig. 34e : Blackgram+ sesame intercropping (2:2)

Fig. 34 : Performance intercropping systems during *kharif* at Kochariya

Rainwater harvesting and recycling

The existing *nadi* (rainwater harvesting structure like farm pond) in the village was renovated. The stored water in the *nadi* during *kharif* was efficiently utilized for supplementary irrigation of 7.5 cm during reproductive stages of the maize (Fig. 35) and groundnut crops with their respective intercropping systems and yield increase with supplemental irrigation was upto 51.1% compared to no irrigation.

A farm pond size of 18x30x3 m having capacity 1242 m^3 without lining was dug for efficient rainwater

Fig. 35 : Maize + blackgram (2:2) with supplemental irrigation

Table 45 : Performance of intercropping systems with supplemental irrigation

Crop	Variety	Yield (kg/ha)		% increase in yield	Net returns (Rs/ha)	BC ratio
		Supplementary irrigation	Without irrigation			
Maize + blackgram (2:2)	PM-3 & T-9	2670	2380	12.18	3265	3.07
Groundnut + sesame (6:2)	TG 37-A & RT-46	1931	1278	51.09	18650	4.69

harvesting and recycling (Fig. 36a, 36b). Similarly, a farm pond of size 116 x 12 x3 m having capacity 240 m^3 with cement concrete were also constructed after start end of *kharif* season.

Timely operations through Custom Hiring Center

A custom hiring center was established in both the villages with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements viz.; Reversible Disc plough, MB Plough, Intercropping seed drill, Multi crop seed drill, Two row seed drill, Hand seed drill, Arjia wheel hoe, Single row power weeder (Four stroke), Single row power weeder (Two stroke), Three row power weeder, Battery operated power sprayer, and Chaff Cutter (Electric) gave higher output energy and crop yield compared to normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period (Table 46). Various agricultural operations with hired implements are shown in Fig. 37

Fig. 36a : Pacca Farm pond

Fig. 36b : Kaccha Farm pond

Table 46 : Efficiency of various farm machinery/ equipments

Type of machinery/ equipments used	Type of farm operation	Area covered, ha (Number of farmers)	Diesel consu-mption (lit/hr/ operation)	Purpose
Reversible Disc plough	Primary tillage	5 ha (11)	3.3	To eliminate the dead furrow
M B Plough	Primary tillage	1 ha (4)	4.1	Rain water conservation
Intercropping seed drill	Sowing	2 ha (4)	1.2	Sowing of intercropping system by tractor else it was not possible
Multi crop seed drill	Sowing	11.5 ha (27)	1.2	Sowing of groundnut and gram by tractor, else it was not possible
Two row seed drill	Sowing	19 ha (3)	1.25 ha /day/ bullock power	To improve the timeliness of sowing by bullock power
Hand seed drill	Sowing	1 ha (1)	0.25 ha / two person	Suitable for marginal farmer for timely sowing
Arjia wheel hoe	Inter-culture	36.25 ha (30)	0.09 ha/hr/ person	To reduce drudgery and improve the efficiency of interculture operation
Single row power weeder (Four stroke)	Inter-culture	4 ha (7)	0.5	To reduce drudgery and improve the efficiency of interculture operation
Single row power weeder (Two stroke)	Inter-culture	2 ha (5)	0.65	To reduce drudgery and improve the efficiency of interculture operation
Three row power weeder	Inter-culture	6, 5 ha (6)	0.7	To reduce drudgery and improve the
Battery operated power sprayer	Spraying	5.5 ha (31)	8 hrs per charging	To reduce drudgery
Chaff Cutter (Electric)	Chaff cutting of fodder	4 ha (4)	2 KWH	For value addition

Multicrop seed drill for sowing

Arjia wheel hoe for interculture

Weeding with wheel hoe

Disc plough for primary tillage

Fig. 37 : Various agricultural operations with hired implements

Alternate land use and Eco-system services

The fodder availability is scarce due to drought in this region. Keeping this in view and for risk minimization and higher land productivity per unit area, a ber based horti-pastoral system with trench system of plating was demonstrated in farmers' field (Fig. 38). Similarly, an on-farm improved silvi-pasture model on non-arable land in 1.2 ha was demonstrated with full package of practices. The major components of the model consist of forages (*Cenchrus setgerus - CAZRI-76*) with tree components. *In-situ* rainwater management with contour trenches at 8 m interval was demonstrated to stabilize the yields. The improved grasses with *in-situ* moisture conservation produced a grass yield of 8000 kg ha^{-1} as compared to local grass (4600 kg/ha) during the very first year of establishment (Fig. 39). The improved practice gave net returns of Rs. 13950 /ha with BC ratio of 2.39 in comparison to farmers practice (Table 47).

Climate change need to be tackled both short-term and long-term strategies. These systems are gradually attracting farmers' attention and to adopt such interventions to cope with climate variability in the region.

Fig. 38 : Improved practice - Trench planting

Fig. 39 : Farmer with a good harvest of cenchrus setigerus

Table 47 : Yield and economics of silvi-pastoral system

Grass	Treatments	Yield (kg/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
Cenchrus setigerus	Improved practice	8000	24000	13950	2.39
Local grass*	Farmers' practice	4600	4600	2200	1.92

*Yield of grass is benchmark yield

1.2.2 BALLOWAL SAUNKHRI

a. Agro-ecological setting

Ballowal Saunkhri is located in Kandi zone in Punjab. Annual average rainfall is 1012 mm. Annual potential evapo-transpiration is 739 mm.

b. On-station experiments

At Ballowal Saunkhri, the onset of monsoon was on 26th June which was one week early than normal onset. A rainfall of 1437 mm was received during cropping period as against normal of 1003 mm (Fig. 40). However, an excess rainfall of 274.2 and 115.8% was received during June and August, respectively over normal. Further, a deficit rainfall was noticed during July, September, October, November and December months to the tune of 30.7, 20.9, 100, 100 and 32 per cent, respectively over the normal rainfall.

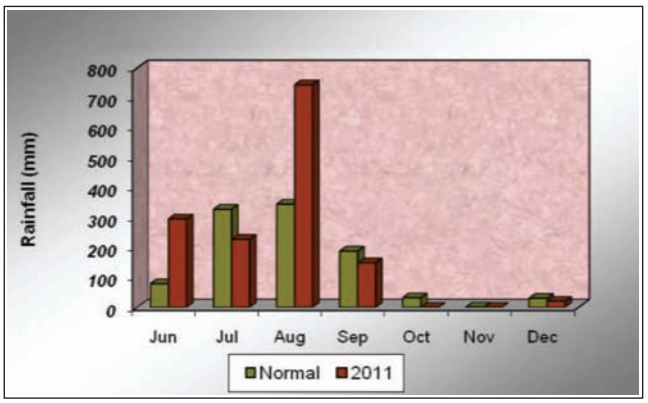

Fig. 40 : Normal and actual (2011) monthly rainfall at Ballowal Saunkhri

Real time contingency planning

Despite dry spell during July and September and excess rainfall during June and August, introduction of maize hybrid JH 3459 yielded better (2734 kg/ha) with RWUE (3.69 kg/ha/mm) and BC ratio of 2.04 (Table 48).

Maize + blackgram system performed better and sustained the excess rainfall events and dry spells during the cropping season. Further, this system recorded higher yield (2191 kg/ha), RWUE (2.95 kg/ha/mm), net returns (Rs. 10,333/ha) and BC ratio (1.56) (Table 49).

Table 48 : Performance of improved maize varieties under early onset of monsoon and mid season drought situation

Crop	Variety	Crop duration	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
Maize	JH 3459	81	2734.4	0.210	3.688	17879	36423	18544	2.04
	Parkash	81	1950.6	0.158	2.631	17879	28280	10401	3.04
	Local	81	1491.7	0.105	2.012	17879	25215	7336	1.04
	PMH 2	81	2392.6	0.150	3.227	17879	35281	17402	1.97
	Partap	81	2061.7	0.262	2.780	17879	26014	8135	1.45
	Local (Himachal)	81	3814.8	0.174	5.145	17879	53595	35716	3.00

Seasonal rainfall: 741.5 mm

Table 49 : Performance of maize based cropping systems under early onset of monsoon and mid season drought situation

Sequence cropping/ Intercropping system	Crop/ variety	Seasonal rainfall (mm)	Yield (kg/ha) Y1+Y2	RWUE (kg/ha/mm)	Cost of cultiva-tion (Rs/ha)	Gross returns (Rs/ha) from C1&C2	Net returns (Rs/ha)	BC Ratio
Maize – blackgram system	Maize JH 3459	769.7	3674.80	4.77	17879	46857	28978	2.62
	blackgram 114	769.7	1569.70	2.03	13184	50231	37047	3.81
Maize based intercropping	Maize (Sole)	741.5	2009.78	2.71	17879	28359	10480	1.59
	Maize+ blackgram	741.5	2191.34	2.95	18379	28712	10333	1.56
	Maize+ greengram	741.5	1797.41	2.42	18379	24497	6118	1.33

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

The rainwater was harvested and stored in a farm pond (Top: 23 x 26 m Bottom: 17–20 m Side slope: 1:1) with capacity of 1300 m^3 and catchment and command area of 3.57 ha and 1.3 ha, respectively. Two irrigations of 5 cm each time was given to the component crops viz., maize, sesame,blackgram in the alternate land use systems viz., (agriculture + trees on boundary and agriculture + trees in block plantation) This, resulted in higher yield of maize, sesame, blackgram with BC ratio up to 1.88. Agriculture + tree in block plantation is found to produce more yield, RWUE, net returns and BC ratio as compared to Agriculture + trees on boundary situation (Table 50).

Performance of maize (JH 3459) with *in-situ* moisture conservation practices

In-situ moisture conservation practices in maize i.e. compartment bunding increased soil moisture by 13.5 %, summer ploughing upto 25.44%, sowing across the slope by 15.38 % and earthing up upto 63% compared to no compartment bunding, no summer ploughing and no earthing up (Table 51).

Table 50 : Efficient utilization of harvested rainwater in alternative land use systems

Crop/ Variety	Yield (kg/ha)	RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Situation-I (Agriculture + trees on boundary)						
Maize (JH 3459)	3388	6.25	22710	41468	18757	1.83
Sesame (TC 289)	288	0.53	12691	15264	2573	1.30
Blackgram (Mash 338)	772	1.42	15041	25762	10721	1.71
Situation- II (Agriculture + trees in block plantation)						
Maize JH 3459	3370	6.22	22700	42653	19953	1.88
Sesame TC 289	367	0.68	12947	19486	6539	1.51
Blackgram + Kinnow* Mash 338	504	0.93	10529	16749	6220	1.59
Blackgram + Guava* Mash 338	507	0.93	10529	16889	6361	1.60

Seasonal rainfall: 543mm

Table 51 : Impact of *in-situ* moisture conservation practices on maize yield, RWUE and Economics

In-situ conservation practices	% increase in soil moisture over control	Yield (kg/ha)	RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
CB	13.15	4500.9	6.070	17879	52911.8	35032.8	2.96
NCB		3861.1	5.207	17879	46826.4	28947.4	2.62
SP	20.45	3250.9	4.224	17879	44897.9	27018.9	2.51
NSP		1320.4	1.715	16879	18674.3	1795.3	1.11
SP	11.49	5981.9	9.396	17879	88886.5	71007.5	4.97
NSP		3833.3	4.980	16879	50270.8	33391.8	2.98
SP	25.44	5684.7	7.667	17879	67790.6	49911.6	3.79
NSP		4138.9	5.582	16879	49322.9	32443.9	2.92
Sowing along slope		3235.2	4.363	17879	38570.8	20691.8	2.16
Sowing across slope	15.38	3876.9	5.228	17879	45924.3	28045.3	2.57
No earthing- up		3624.1	4.887	17879	42956.3	25077.3	2.40
Earthing up with wheel hoe	30.64	3273.1	4.414	17879	39170.1	21291.1	2.19
Earthing up manually	63.19	3785.2	5.105	17879	44481.9	26602.9	2.49

CB- Compartment bunding ; NCB- No Compartment bunding ; SP- Summer ploughing; NSP- No Summer ploughing

Alternate land use / farming systems for carbon sequestration and ecosystem services

An experiment on guava and aonla based agri-horti system with annual crops is in progress. The BC ratio with taramira + guava is 2.57 and aonla + taramira is 1.60 compared to sole taramira i.e. 2.22 and 1.44, respectively (Table 52). Results revealed that, taramira + guava system recorded higher net returns (Rs. 10,468/ha) and BC ratio (2.57) as compared to other systems.

Amla + taramira agri-horti system gave a net returns of Rs 4537 compared to Rs. 4431 with sole cropping of taramira (Table 53)

Table 52 : Performance of guava based agri-horti system

Treatments	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net Returns (Rs/ha)	BC Ratio
	Fruit	Crop				
Kharif						
Guava + greengram	-	257	6592*	8995*	2403*	1.36
greengram	-	322	14823	11270	-3553**	0.76
Rabi						
Guava + taramira	-	489	6659*	17127	10468	2.57
Taramira	-	630	9917	22050	12133	2.22

* cost of cultivation/ return of green gram; ** Due to attack of blister beetle

Table 53 : Performance of amla based agri-horti system

Treatments	Yield (kg/ha)		Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
	Fruit	Crop				
Amla + taramira	-	489	7615*	12152*	4537*	1.60
Taramira	-	630	10059	14490	4431	1.44

* cost of cultivation/ return of taramira

C. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Ballowal-Saunkhri in Achalpur, and Nainwan villages inl Garhshankar tehsil in Hoshiarpur district, Punjab. The total cultivated area is 145.2 hectares in Achalpur and 320 hectares in Nainwan, out of which the rainfed area is 102 ha in Achalpur and 288.5 ha in Nainwan. The mean annual rainfall is 1081 mm with the seasonal rainfall of 903.7 mm during *kharif* (June- September). The major soil types are silt loam (silty clay loam) in texture. The major rainfed crops during *kharif* season are maize and sorghum and in *rabi* are wheat, raya and taramira. The small, marginal, medium and large farmers are 86, 11, 3 and 0% in Achalpur and 76, 13, 6 and 5% in Nainwan, respectively. Only one tube well is available in each village as a source of irrigation, which is covering 10% of cultivated area approximately.

Climate Variability in General

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 1081 mm, the south-west monsoon contributes 80 %, north-east monsoon 12 % and summer 8%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 43% deficit of the average rainfall. The onset (south-west) of monsoon was during 24 SMW and north-east monsoon was 40 SMW. For the past 15 years, the dry spells during crop season were experienced in the month of September at grain filling stage of *kharif* crops. The normal onset of the monsoon was first July and generally delayed by one week influencing the sowing of maize and its productivity. The soil moisture was generally deficit at sowing and at reproductive stages of *rabi* crops. The maximum and minimum temperature during *kharif season* ranged from 31.9 to 40.8^{o}C and 21.4 to 26.2^{o}C, whereas during *rabi* season it varied from 16.0 to 38.9^{o}C and 2.3 to 20.4^{o}C, respectively in past 10 years.

The area had been experiencing extreme events like hail storm and frost during *rabi*.

Experienced weather conditions during the year (2011-12)

The villages received 868.2 mm of rainfall, which was deficit of 212.8 mm compared to normal rainfall (1081 mm) (Fig. 41). The onset of monsoon was normal. The maximum temperature during *kharif* season ranged from 26.8 to 40.5^{o}C with extreme at 20 SWM and minimum temperature varied from 11.3 to 25.5^{o}C with lowest at 46 SWM. During *rabi* season, maximum temperature varied from 11.2 to 37.2^{o}C with extreme at 17 SWM and minimum from 3.8 to 19.9^{o}C with lowest at 4 SWM,

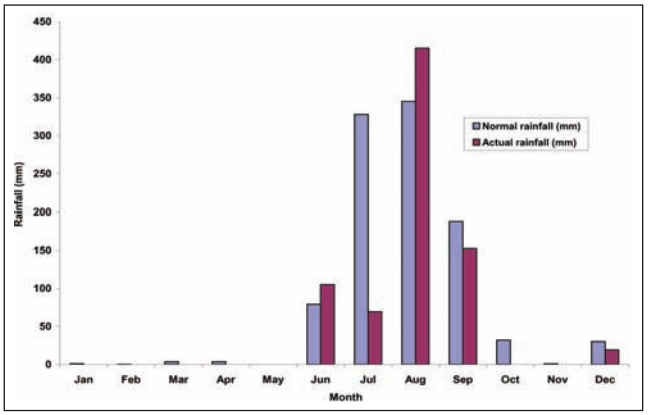

Fig. 41 : Normal and actual (2011) monthly rainfall at Achalpur Village

respectively. The crops experienced dry spells during October and November months (40-47 SWM), which impacted the sowing of *rabi* crops.

Interventions

The major interventions were implemented include land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services.

Land configuration

The summer ploughing and ploughing across slope, which enhanced *in-situ* moisture conservation and resulted in higher maize yield by 19% and rainwater use efficiency by 23% through summer ploughing compared to farmers' practice while ploughing across the slope in maize increased the grain yield only by 3%, but significantly improvement was observed in rain water use efficiency (Table 54).

Crops/Varieties/Cropping system

a. *Kharif*

The drought tolerant hybrids/varieties of maize (JH3459 and Parkash) (Fig. 42a, 42b), pearlmillet (FBC 16), blackgram (Mash 114) and sesame (RT 346) were introduced in both Achalpur and Nainwan to cope with the rainfall variability of the region. The yield increase with the these varieties was up to 11.5, 32, 7.8 and 7.1% and with BC ratio of 2.5, 2.5, 1.4 and 2.4 respectively in maize, pearlmillet, blackgram and sesame, respectively over the local cultivars (Table 55).

b. *Rabi*

Though there was a initial dry spell during sowing of the *rabi* crops *viz.*, wheat and raya, introduction of improved varieties of wheat (PBW 175), raya (RLM 619 and PBR-97) and taramira (TMLC 2) produced 68 %, up to 2.05 % and 1.85 % , higher yield over local cultivars respectively (Table 56).

Table 54 : Effect of *in-situ* moisture conservation practices on maize yield

Component	Crop	Hybrid	Yield (kg/ha)		% increase	RWUE (kg/ha/mm)	BC ratio
			Improved practice	Farmers' practice			
Summer ploughing	Maize	JH-3459	4211	3533	19	6.20	2.84
Ploughing across slope	Maize	JH-3459	3602	3533	3	5.48	2.41

Table 55 : Performance of drought tolerant hybrids / varieties

Crop	Variety	Yield (kg/ha)		% increase	BC ratio
		Improved practice	Farmers' practice		
Maize	JH-3459	3681	3300	11.5	2.5
Maize	Prakash	3394	3300	2.8	2.3
Pearlmillet	FBC-16	41250	31250	32.0	2.5
Blackgram	Mash-114	566	525	7.8	1.4
Sesame	RT-346	375	350	7.1	2.4

Fig. 42a : Maize-JH-3459

Fig. 42b : Maize - Local cultivar

Table 56 : Performance of improved varities of rabi crops under initial dry spell

Crop	Variety	Yield (kg/ha)		% increase in yield	BC Ratio
		Improved practice	Farmers' Practice		
Wheat	PBW 175	2320	1380	68.1	2.5
Raya	RLM 619	1300	850	52.9	2.05
	PBR 97	1000	900	11.1	1.96
Taramira	TMLC 2	620	600	3.3	1.85

Rainwater harvesting and recycling

A participatory appraisal was done in Nainwan village (Fig. 43) to assess the potential of rainwater harvesting in the existing farm pond of the village. Accordingly, during the reporting period, the farm pond was renovated to storage capacity of 190000 cu. ft (Fig. 44). The harvested and stored rainwater is likely to be efficiently utilized for supplementary irrigation/life saving irrigation to rainfed crops during *kharif* and *rabi*.

Fig. 43 : Participatory appraisal of catchment area and run off potential of the existing farm pond in Naiwan village

Fig. 44 : Renovated pond at Nainwan

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. Custom hiring committee of the village comprised of 12 members from farming community including male and female farmers.

Alternate land use and eco-system services

For crop diversification and higher returns, vegetable crops like ash gourd was introduced in both the villages (Fig. 45). Ash gourd gave fruit yield of 37500 kg/ha and 25000 kg/ha in Achalapur and Naiwan respectively and fetched good income to the farmers.

Fig. 45 : Ash gourd - Nainwan village

At on-station, agri-horti system with maize, sesame, blackgram were also demonstrated. Trees were planted on boundary of the field as well as in block plantation to get additional income from the field (Table 57 & 58).

In kandi region, to cope with rainfall variability and extreme events, agri-horti system has greater scope as a short term and long term adaptation strategy for risk minimization and higher land productivity. The farmers are convinced to adopt this system, particularly medium and large farmers due to large land holdings.

Table 57 : Performance of improved varieties of ash gourd

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross returns	Net returns (Rs/ha)	BC Ratio
Ash gourd	Private	37500	52.56	9000	75000	66000	8.33
Ash gourd	Private	25000	35.66	9000	50000	41000	5.56

Table 58 : Performance of *kharif* crops, RWUE and economics in agri-horti system

Crop	Variety	Yield (kg/ha)	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Situation – I (Agriculture + trees on boundary							
Maize	JH-3459	3388	6.25	22710	41468	18757	1.83
Sesame	TC-289	288	0.53	12691	15264	2573	1.30
Blackgram	MASH-338	772	1.42	15041	25762	10721	1.71
Mean			**2.70**	**16814**	**27498**	**10683**	**1.60**
Situation – II (Agriculture + trees in block plantation)							
Maize	JH-3459	3370	6.22	22700	42653	19953	1.88
Sesame	TC-289	367	0.68	12947	19486	6539	1.51
Balayn + Kinnow*	Mash-338	504	0.93	10529	16749	6220	1.59
Guava*	Mash-338	507	0.93	10529	16889	6361	1.60
Mean		**1187**	**2.19**	**14176**	**23944**	**9768**	**1.65**

1.2.3 RAKH DHIANSAR

a. Agro-ecological setting

Rakh Dhiansar is located in Western Himalayas of South Kashmir and Kumaon, warm moist to dry sub-humid transitional eco-sub-region (AESR 14.2) and low altitude subtropical agro climate zone in Jammu & Kashmir. Annual average rainfall is 800mm. Annual potential evopotransportation is 1100mm. Length of growing period is 150 - 210 days.

b. On-station experiments

At Rakh Dhiansar, the onset of monsoon was normal on 24th June. A rainfall of 1275 mm was received during cropping period as against normal of 860 mm in 2011. However, an excess rainfall of 237.8, 13.5 and 92% was received during June, July and August months, respectively over the normal rainfall of these months. Further, a deficit rainfall of 7.5, 43, 96.9 and 94.8% was observed during September, October, November and December months respectively.

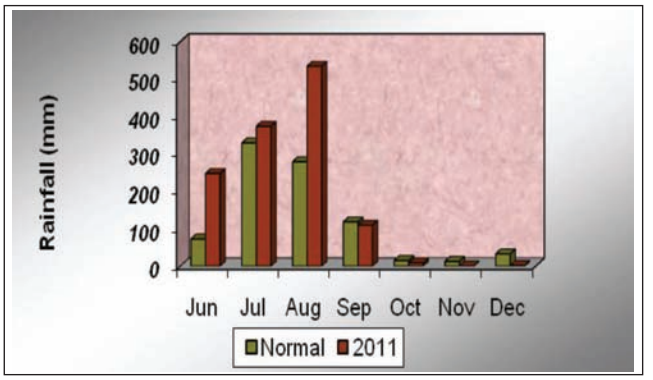

Fig. 46 : Normal and actual (2011) monthly rainfall at Rakh Dhiansar

Efficient energy use and management

The maize sowing with the liner consumed maximum energy and resulted in maximum grain and straw yield as compared to maize planter and broadcasting. But the cost benefit ratio was found higher in case of sowing of maize with maize planter as compared to liner and broadcasting due the labour component (Table 59).

The total energy required by sowing with liner was maximum as compared to seed cum fertilizer drill and broadcasting, whereas the grain and straw yield of wheat found highest when sowing of wheat with seed cum fertilizer drill and lowest in case of sowing of wheat with broadcasting**.** The higer BC ratio (1.8) was with seed drill sowing method (Table 60).

Table 59 : Economics and energy equivalent requirement of maize (Kanchan hybrid) and their BC ratio

Name of the equipment	Yield (kg/ha)		Total energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	BC ratio
	Grain	Straw					
Broadcasting	1050	1552	8813.33	34835	18316.6	13627	0.74
Sowing with liner	1540	2260	9463.60	50888	21426.9	19970	0.93
Maize planter	1505	2220	9098.86	49873.5	17762.5	19527.5	1.10

Rate of Maize grain = Rs. 11.50/kg Rate of maize stover = Rs. 1.00/kg

Table 60: Yield and economics under different practices of sowing of wheat (PBW-175) during *rabi* 2011

Name of the equipment	Yield (kg/ha)		Total energy requirement (MJ/ha)	Total energy output (MJ/ha)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	BC ratio
	Grain	Straw					
Broadcasting	1071.4	1875	6627.51	39187.52	10581	16928.6	1.60
Sowing with liner	1116.1	2187.5	6930.04	43749.98	11301	18102.7	1.60
Seed cum fertilizer drill	1339.3	2410.7	6712.75	50062.38	11860	21294.7	1.80

Rate of wheat grain= Rs. 12.30/kg, rate of wheat straw= Rs. 2.00/kg

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre,Rakh Dhiansar in Khaner village, Purmundal Block, Tehsil & District Samba, Jammu and Kashmir State. The total cultivated area is 55 ha and 100% of the area is rainfed. The mean annual rainfall is 1140 mm with seasonal rainfall of 860 mm during *kharif* season (June-September). The major soil types are sandy loam. The major rainfed crops during *kharif* are maize, blackgram, greengram, sesame, fodder pearlmillet, fodder sorghum and during *rabi* season are wheat, chickpea and mustard. The number of small, marginal and medium farmers is 40, 18 and 32, respectively. The ground water table is 150-200 meters. There is no source of irrigation in the village.

Climate Variability in General

In general, climate in this agro-climatic zone is sub-humid. The rainfall is received through south-west monsoon (monsoon season), western disturbances (winter season) and summer (pre-monsoon) and contributes about 75, 13 and 12% of the annual rainfall. The historical rainfall data (of 25 years) indicated that the variability among normal rainfall during south-west monsoon is 26.2 and 17.5 % surplus and deficit, respectively. The normal onset of (south-west) monsoon was during 26th SMW. For the past 15 years, the dry spells during crop season were experienced were 1, 5 and 6 during August, September and October, respectively and at initial and reproductive stages of the major rainfed crops. There was a 20 % probability of occurrence of severe drought during *rabi* season in *kandi* belt of Jammu region. The chances of occurrence of normal and moderate drought were 7 and 12% during *kharif* season and 8 and 8% during *rabi* season, respectively. In the district, the chances of normal season were more than 60% during crop growing season, whereas, the chances of normal (25% less from normal rainfall) and moderate (25-50% less from normal rainfall) drought were 24 and 12%, respectively. The chances of early, normal and late onset of monsoon are 16, 72 and 12%, respectively; whereas 28, 68 and 4% chances of early, normal and late withdrawal of monsoon, respectively. The soil moisture status remain deficit during establishment and reproductive stages of major rainfed crops in different years in the region with a lot of variability among the above said crop stages. The data on maximum/minimum temperature during *kharif* crop season is 34.3/23.7^{O}C and during *rabi* season the maximum/minimum temperature is 24.7/10.3^{O}C for the past 10 years. There was increase in the maximum temperature during *kharif* season at the rate of 0.03^{O}C per year while during *rabi* season the mean temperature had also gone up by 0.04^{O}C per year. The day temperature in the district decreased by 0.7^{O}C from the last two decades while the night temperature had gone up by 0.6^{O}C during this period. The rainfall showed an increasing trend at the rate of 2.0 mm per year for the past 20 years. The extreme events like unusual and high intensity rainfall in short span had been increasing in the month of August. The region had been also experiencing other extreme events like floods and cold waves. There was no shift in rainfall pattern in the region and hence sowing window remained same.

Experienced weather conditions during the year (2011-12)

The village received 1263 mm rainfall during south-west monsoon, which was 408 mm above normal (47.7%) (Fig. 47). The onset of monsoon was normal (26th SMW). During *rabi*, the rainfall was 165 mm which was deficit by 28.3 mm than the normal (193.5 mm). The intense

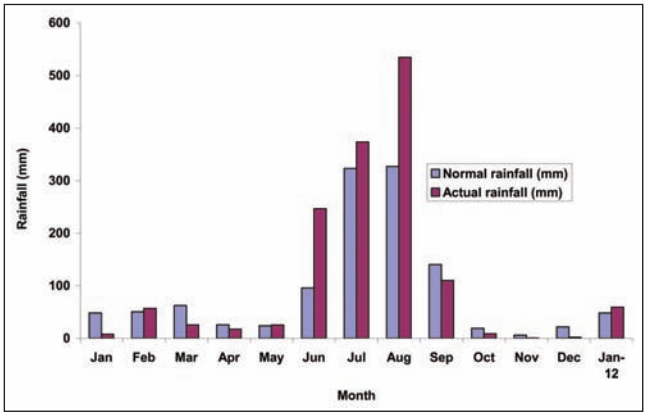

Fig. 47 : Normal and actual (2011) monthly rainfall at Khaner Village

rainfall events amounting to 272.1 mm were experienced during 32nd SMW (August) which had an adverse impact on the performance of maize, sesame, blackgram and greengram. There was a lot of fluctuation in maximum temperature during *kharif* at different crop stages *i.e.* 5 to 7^{O}C below normal from 25-28th August, 2011 while minimum temperature remained above normal by 5^{O}C during the early establishment of *kharif* crops (26th SMW). During *rabi* season, the mean temperature remained above normal by 2^{0}C during 2011-12.

Interventions

The major interventions were implemented include varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 10.3 ha in 52 farmers' fields.

Crops/Varieties/Cropping systems

The onset of south-west monsoon was normal and there was no dry spell during the cropping season *(kharif)*. However during *rabi* season, sowing of crops affected, further, the rabi crops experienced early season drought. The suitable varieties/hybrids of maize (K-99, K-9451, Shakthiman, K-517), cowpea (C-475) of sesame (Pb til-1) and blackgram (Mash-114), (K-99, K-9451, Shakthiman, K-517) wheat (PBW-175), mustard (RSPR-01) and chickpea (GNG-469) were introduced to cope with rainfall variability of the region. Despite four excess rainfall events (102.6 mm (7th July), 103.7 mm (8th August), 108.0 mm (11st August) and 96.0 mm (13rd August, 2011), the improved varieties/hybrids of maize performed better (Fig. 48a, 48b) with increase in yield up to 22.7 % and RWUE up to 2.15 kg/ha/mm compared to local varieties (Table 61).

There was dry spell during 16th September, 2011 to 7th January, 2012. Even then, the improved varieties of wheat (Fig. 49a, 49b), mustard (Fig. 50a, 50b) and chickpea performed better the yield increase was 22.8%, 28% and 24.4%, respectively compared to the local varieties (Table 62).

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements during the current year and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements *viz.,* liner, seed-cum-fertilizer, khurpis were made available to the farmers for different operations which resulted in higher output energy and crop yield as compared to the normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period sowing maize with liner (Fig. 51a) gave better yield compared broadsasting (Fig. 51b). Sowing wheat with seed-cum-fertilizer drill not only gave a good crop stand but also gave higher net returns (Fig. 52a, 52b) (Table 63 & 64).

Table 63 : Performance of maize hybrids/varieties (under excess rainfall events)

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha/mm)	BC ratio
		Improved practice	Farmers' practice			
Maize	K-99	2108	1765	19.4	1.88	0.98
	K-9451	1913	1610	18.8	1.84	0.86
	Shaktiman	2300	1875	22.7	2.15	1.06
	K-517	1713	1485	15.4	1.65	0.66
Mean	2008	1684	19.2	1.88	0.89	

Fig. 48a : Maize crop under excess rainfall

Fig. 48b : Maize crop after draining excess water

Alternate landuse system

Aonla based agri-horti system with mixed fodder and gobhi sarson were demonstrated in farmers' fields. These interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies.

Table 62: Performance of improved varieties of *rabi* crops under dry spell

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved practice	Farmers' practice		
Wheat	PBW-175	1891	1540	22.8	1.62
Mustard	RSPR-01	717	560	28.0	0.52
Chickpea	GNG-469	628	505	24.4	0.50

Fig. 49a : Wheat - PBW -175

Fig. 49b : Wheat - Local

Fig. 50a : Mustard - RSPR -01

Fig. 50b : Mustard - Local

Table 63 : Performance of improved implements in maize

Implement	Crop	Variety	Energy (MJ) for improved implement		Energy (MJ) for normal implement		Net returns (Rs/ha)	BC ratio
			Input	Output	Input	Output		
Manually (Broadcasting)	Maize	K-517	-	-	8813	34835	11539	0.63
Liner			-	-	9464	50888	16915	0.79
Maize Planter			9099	49874	-	-	16536	0.93

Fig. 51a : Line sowing of maize with Liner

Fig. 51b : Sowing of maize - broadcasting

Table 64 : Performance of improved implements in wheat

Implement	Crop	Variety	Energy (MJ) for improved implement		Energy (MJ) for normal implement		Net returns (Rs/ha)	BC ratio
			Input	Output	Input	Output		
Manually (Broadcasting)	Wheat	PBW 175			6628	39188	16071	1.03
Liner	Wheat	PBW 175			6930	43750	17210	0.93
Seed cum Fertilizer Drill	Wheat	PBW 175	6713	50062			20223	1.59

Fig. 52a : Sowing of Wheat with seed-cum-fertilizer drill

Fig. 52b : Good crop stand of Wheat sown with seed cum fertilizer drill

1.3. Fingermillet Based Production System

1.3.1. BANGALORE

a. Agro-ecological setting

Bangalore is located in Deccan (Karnataka) plateau of Central Eastern Ghats (AESR 8.2), dry zone in Karnataka. The climate is hot moist semi-arid. Annual average rainfall is 926 mm. Length of growing period is 120-150 days.

b. On-station experiments

A rainfall of 591.3 mm was received during cropping period as against normal of 758 mm in 2011. An excess rainfall of 93.6% was received during August month only over the normal rainfall. However, a deficit rainfall of 69.9, 7.4, 70.7, 27.3, 34.3 and 100% was received during June, July, September, October, November and December months, respectively as compared to normal rainfall (Fig. 53).

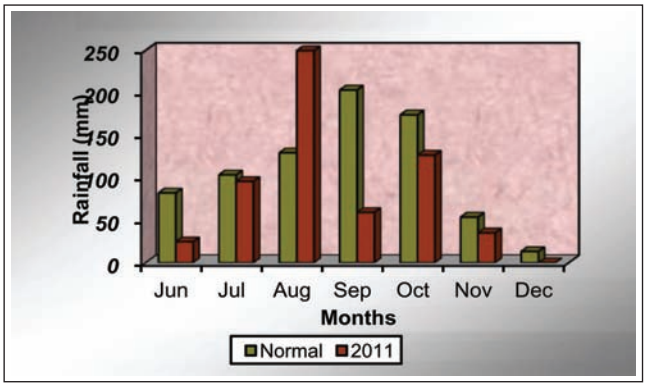

Fig. 53 : Normal and actual (2011) monthly rainfall at Bangalore

Dry land Agri-tech Park

A dryland agri-tech park was established in 3 ha comprising of rainfed technologies under different themes of NICRA project (Fig. 54a, b, c & d). During, National Krishi Mela 2011 nearly 4 to 5 lakh farmers along with officers of the line departments visited, dryland technology park. (Table 65)

Table 65 : Dry land Technology park with improved dryland practices

Pure crops	Yield (kg/ha)
Fodder pearlmillet	25694
Fodder sorghum	16605
Fodder maize	18411
Pigeonpea (May- I fortnight) TTB-7	1937
Pigeonpea (May- I fortnight) BRG-2	1861
Pigeonpea – Transplanting	139
Groundnut-cv(TMV 2). Chintamani-2	562
Groundnut-cv(TMV 2). Chintamani-2	520
Groundnut cv. Narayani	722
Maize Hybrid NAH-2049 Nithyshree	3811
Maize Hybrid 1137 Hema	4850
Sunflower KBSH 53	1979
Niger 71	263
Chilli Samrudhi	1883
Chilli Chikkaballapur local	1050
Cowpea IT 38956-1	1055
Cowpea PKB-4	1172
Cowpea PKB-6	1236
Fieldbean (HA-4)	805
Rice Bean	1388
Horsegram (PHG-9)	679
Non nipped Castor	563
Nipped Castor	1459
Grain amaranth	1875
Horsegram -Fingermillet	4482
Glyricidia- Fingermillet	4192
Dry sowing of Fingermillet	3991
Fingermillet ML-365	4392
Kodomillet	2508
Foxtailmillet	729
Littlemillet	986
Barnyardmillet	501
Prosomillet	494

Fig. 54a : Dryland Agriculture Technology park

Fig. 54b: Performance of groundnut genotypes in Agri-Tech park

Fig. 54c : Performance of varieties of fingermillet under contingent crop planning

Fig. 54d : Transplanted Pigeonpea (BRG 2) in Agri-Tech park

Real Time Contingeny Planning

The real-time contingency measures adopted due to delayed on-set of monsoon and dry spells are given in Table 66.

Table 66 : Contingency measures adopted under delayed onset of monsoon and dry spells

S.No.	Month	Weather aberration	Contingency measures
1.	June	Due to delay in the monsoon	Pigeonpea nursery taken up in plastic covers and transplanted after 35 days after the receipt of rains
2.		Dry spell	Thinning, intercultivation and weeding was done in May sown Pigeonpea, fieldbean and cowpea.
3.		Due to delay in the monsoon	Fingermillet nursery (MR-1) taken up and transplanted after 21 days after the receipt of rains
4.		Due to delay in the monsoon	Medium duration fingermillet variety GPU-48 was sown in the Dryland Agri Tech Park.
5.		Excess runoff rain water	Collected in the farm pond and used for protective irrigation to horticulture crops around the pond
6.	June 1st fortnight and 2nd August	Real time contingent crop planning	Long duration variety, viz., MR-1, medium duration variety, viz. GPU-66 and short duration variety, viz. GPU-48 were sown at fortnightly interval, Gaps were filled by transplanting, Thinning, interculti-vation and weeding was carried out.
7.	August	Dry spell in July	Fieldbean and cowpea were harvested for vegetable purpose and biomass incorporated between two lines of pigeonea in pigeoanpea + fieldbean (1:1) and pigoenpea + cowpea (1:1) intercropping system

The performance of short, medium and long duration varities of fingermillet under realtime contingency planning from second fortnight of June to second fortnight of August 2011, is presented in Table 67. In sesame based double cropping system sesame cv ST-9-1 performed better while in cowpea based double cropping system, cowpea cv. IT38956-1, performed better (Table 68). In pigeonpea based inter cropping system, pigeonpea (TTB-7) + grain amarnath performed better while in groundnut based intercropping system, groundnut + nipped caster performed better. Further fingermillet + pigeonpea (8:2) found to be better (Table 69).

Table 67 : Performance of short, medium and long duration varieties of fingermillet under real time contingency crop planning

Situation	Fingermillet/variety	Yield (kg/ha)
June 2nd Fortnight Fingermillet		
	GPU-48	2701
	GPU-66	2804
	MR-1	3303
July 1st Fortnight Fingermillet		
	GPU-48	2993
	GPU-66	3201
	MR-1	3803
July 2nd Fortnight Fingermillet		
	GPU-48	3102
	GPU-66	3351
	MR-1	3999
August 1st Fortnight Fingermillet		
	GPU-48	3250
	GPU-66	3499
	MR-1	3800
August 2nd Fortnight Fingermillet		
	GPU-48	3301
	GPU-66	3796
	MR-1	3982

Table 68 : Performance of sesame and cowpea double cropping system

Double cropping	1st crop yield (kg/ha)	2nd crop yield (kg/ha)
Sesame (ST-9-1) - finger millet	441.67	2810.0
Sesame chandana Horse gram	427.08	455.20
Cowpea (May) (PKB-4) - fingermillet	1006.94	3201.0
Cowpea (May) (IT38956-1) - fingermillet	1423.61	3179.0

Table 69 : Performance of pigeonpea, groundnut and fingermillet based intercropping systems

Intercropping	Main crop yield (kg/ha)	Inter crop yield (kg/ha)
Pigeonpea (TTB-7) + grain amaranth	1302	669
Pigeonpea (TTB-7) + fieldbean	1388	347
Pigeonpea (TTB-7) + cowpea	1375	556
Groundnut (TMV-2) + pigeonpea (TTB-7)(8:2)	642	365
Groundnut (TMV-2) + nipped castor 8:2)	708	851
Maize (Nithyshree) + pigeonpea (TTB-7) (1:1)	4390	431
Fingermillet + soybean (4:2)	3712	278
Fingermillet + pigeonpea (8:2)	4130	487
Fingermillet + fieldbean (4:2)	4072	335
Fingermillet + grain amaranth (3:1)	3980	432
Farmers practice	3185	0

Rainwater harvesting and recycling

Four farm ponds were earmarked for different purposes *viz.,* crop production, pisiculture, supplemental/ irrigation to horticultural plants planted elsewhere in the farm and to grow vegetables and fruits around the farm pond. From a catchment area of 0.612 ha 52,210 litres of runoff was harvested in the farm pond (Fig. 55) and used to provide two protective irrigations for onion crop in an area of 583.20 m^2. Fish were reared in another pond where water was being collected from a catchment of 0.561 ha where in 242680 litres of water was collected, 30780 litres of water was lifted at different times for two irrigations to onion, leafy vegetables and gourds; By growing different vegetables, an additional income of Rs.1005/- was realized in 2-guntas. However, no protective irrigation was given to finger millet grown in the command area as the crop did not experience drought.

Fig. 55 : Rain water harvesting in farm pond

During 2011, the runoff causing rainfall was 549.9 mm out of 804.5 mm of total rainfall. Runoff water collected from the catchment was 241.72.4 & 232.93 m^3 where no live barrier was there and it was 242.68 m^3 in Nase and 216.24 m^3 in Khus live barrier (Table 70).

Among different vegetable crops, higher yield (10 kg/ 200 m^2) and income (Rs. 402/ 200 m^2) was obtained with Amaranthus (Local) compared to other vegetables. Further, total income from all vegetables was Rs. 1005 (Table 71).

Alternate land use system

Evaluation of Amla based Agri/horti system with cereals and pulses in 2 ha area

Fingermillet, field bean and cowpea were proved to be better intercrops in amla which have registered higher B: C ratio and RWUE. Leguminous intercrops *viz.,* field bean, cowpea and horsegram enhanced the growth parameters, as compared to finger millet, grain amaranthus and fodder maize (Fig. 56) (Table 72).

Custard apple based Agri-horti system in 1 ha area

Fodder maize gave higher RWUE of 85.25 kg/ha/mm (Table 73) (Fig. 57).

Intercrops influenced various growth parameters of custard apple particularly canopy spread and biomass yield (Table 74).

Fig. 56 : Amla based agri-horti system in Agri-Tech park

Fig. 57 : Custard apple based agri-horti system

Table 70 : Amount of water harvested and used for different purposes

Treatment	Catchment Area (ha)	Water harvested (m^3)	Water used (m^3)	Purpose (Supplemental irrigation)
T_1: Life saving irrigation system around the farm pond (Bricks)	0.612	216.14	52.21	Onion (2 irrigation) (Area is 583.20 m^2)
T_2: Fish culture (soil + cement over layed polythene lining and brick compartment)	0.561	242.68	-	Fish rearing (yet to harvest)
T_3: Horticulture components around the farm pond	0.561	232.93	30.78	Gourd, leafy vegetables (200 m^2), Onion (2 irrigations) (Area is 583.20 m^2), banana, curry leaf, drumstick
T_4: Nourishing horticulture crops planted elsewhere	0.594	241.72	11.49	Onion, Pomello, Amla and Custard apple (2.0 ha)

Table 71 : Performance of vegetable crops with supplemental irrigation from harvested rainwater in farm ponds

Crops/Variety	Yield (kg/2 m^2)	Income (Rs)
Bottle gourd	3.5	42
Ridge gourd	4.6	55
Amaranthus: Local	10.0	402
Palak: Local	2.0	96
Amaranthus sp.	4.5	180
Fenugreek: Local	1.8	86
Coriander	1.8	144
Total	**1005**	

Table 72 : Performance of intercrops in Amla based intercropping system

Treatment	Yield (kg/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio	RWUE (kg/ha/mm)
T1 Amla + fingermillet	2610.00	31700	18400	2.38	5.78
T2 Amla + foddermaize	17989.00	17989	1628	1.10	49.71
T3 Amla + fieldbean	886.67	26600	14300	2.16	2.45
T4 Amla + grain amaranth	1286.67	19300	5650	1.41	2.87
T5 Amla + cowpea	810.00	24300	13300	2.21	2.24
T6 Amla + horsegram	653.33	9800	3300	1.51	1.45
T8 Fingermillet	2576.33	32429	19129	2.44	5.87
T9 Fodder maize	27683.33	21683	5322	1.33	59.92
T10 Fieldbean	946.67	28400	16100	2.31	2.62
T11 Grain amaranth	1413.33	21200	7550	1.55	3.15
T12 Cowpea	876.67	26300	15300	2.39	2.42
T13 Horsegram	703.00	10545	4045	1.62	1.56
S Em (±)	278.27				
CD (5%)	816.18				
CV (%)	11.0				

Table 73 : Performance of intercrops in the custardapple based Agrihorti system

Treatments	Grain yield (kg/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio	RWUE (kg/ha/mm)
T1: CA + fingermillet	3031	33341	23453	2.76	5.72
T2: CA + fodder maize	31244	31244	14883	1.91	85.25
T3: CA + fieldbean	955	28650	16350	2.33	3.72
T4: CA + niger	415	14525	5175	1.55	0.94
T5: CA + chillies (Vegetable)	3533	35333	19833	2.28	6.67
T6: CA + cowpea	773	23200	12200	2.11	2.11
T7: CA	0.00	0.00	0.00	0.00	0.00
T8: Fingermillet	3103	34140	24352	2.83	5.86
T9: Fodder maize	32135	32315	15954	1.98	87.68
T10: Fieldbean	1105	33150	20850	2.70	3.81
T11: Niger	445	15575	6225	1.67	1.01
T12: Chilli (Veg)	3889	21190	5690	1.37	7.34
T13: Cowpea	798	23950	12950	2.18	2.18

CA- Custard apple

Table 74 : Growth parameters of custard apple as with various intercrops

Treatment	Plant height (cm)	No. of branches	Stem diameter (cm)	Canopy spread (cm)	Biomass yield (kg/tree)
T1: CA + Fingermillet	189.9	3.6	12.8	151.8	79.5
T2: CA + fodder maize	203.9	3.4	12.9	152.1	81.0
T3: CA + field bean	228.0	3.9	14.7	176.2	98.6
T4 : CA + cowpea	211.8	3.7	13.8	168.0	95.8
T5 : CA + chilli	207.0	3.4	14.2	166.5	85.5
T6 : CA + niger	185.6	2.9	11.8	144.6	75.7
T7 : Sole CA	171.5	2.6	11.4	134.6	64.1

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Bangalore in Chikkamaranahalli village, Nelamangala Taluk in Bengaluru rural district, Karnataka. The total cultivated area is 409.2 ha out of which 367.4 ha is rainfed. The mean annual rainfall is 751.9 mm with seasonal rainfall of 417.8 mm during *kharif* (June-September). The major soil type is sandy clay loam. The major rainfed crops during *kharif* are fingermillet, groundnut and pigeonpea. The number of small, marginal, medium and large farmers' are 48, 144, 7 and 2, respectively. The ground water table is 117 m below surface. The source of irrigation is bore wells covering 4.39 ha of cultivated area.

Climate Variability in General

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 751.9 mm, the south-west monsoon contributes 55.50%, north-east monsoon 33.30 % and summer 11.13%. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 8 per cent *surplus* of the average rainfall. The onset (south-west) of monsoon was during 23rd SMW (June 1st week) and north-east monsoon was 40th SMW. For the past 15 years, the dry spells during crop season were experienced in June, July, August, September and October and at vegetative and reproductive stages of the major rainfed crops. The onset of the monsoon has been shifting to June 2nd week and erratic withdrawal. The soil moisture status was deficit during vegetative and reproductive stages of major rainfed crops. The extreme events like unusual and high intensity rainfall in short span were experienced during *kharif* and *rabi* seasons. The area had been also experiencing other extreme events like hail storm.

Experienced weather conditions during the year (2011-12)

The village received 692.0 mm which was deficit of 59.9 mm compared to normal 751.9 mm during south-west monsoon (*kharif*) (Fig. 58). The onset of monsoon was normal. The crops experienced dry spells during 2nd fortnight of June, August, October and 1st fortnight of September at vegetative and reproductive stages of the crops. The intense rainfall event was experienced on August 16th, 2011 with 100 mm rainfall, however this event had a positive impact on the stand/ performance of crops and further contributed to runoff collection in farm ponds.

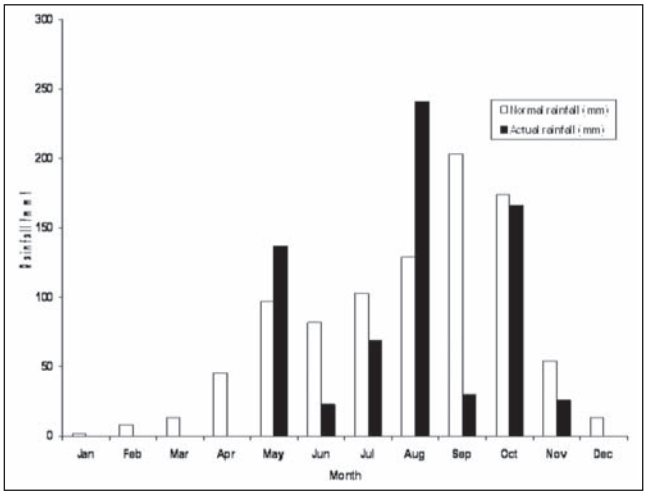

Fig. 58 : Normal and actual (2011) monthly rainfall at Chikkamaranahalli Village

Interventions

The major interventions were implemented both under on-farm and on-station included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use systems. These interventions covered an area of 71.76 ha in 232 farmers' fields.

Land configuration

The land configuration included conservation furrow between rows of pigeonpea in fingermillet + pigeonpea (8:2) and groundnut + pigeonpea (8:2) intercropping systems which enhanced *in-situ* moisture conservation (Fig. 59). This resulted in mitigating dry spells during 2nd fortnight of August, October and 1st fortnight of September at vegetative and reproductive stages of the crops, further enhanced the yield of fingermillet (2667 kg/ha) and pigeonpea (417 kg/ha) with rainwater use efficiency by 6.22 kg/ha/mm compared to farmers practice (3.97 kg/ha/mm). While, groundnut (TMV-2) + pigeonpea (TTB-7) in 8:2 ratio with conservation furrow (Fig. 60) was superior with maximum pod equivalent yield (2072 kg/ha), RWUE (3.59 kg/ha/mm), net returns (Rs. 40506/ha) and B:C ratio (3.32) while the the farmer's practice (Fig. 61) of sole groundnut produced pod yield (5.47 kg/ha), RWUE (0.95 kg/ha/mm), net returns (Rs. 816/ha) and B:C ratio (1.06) (Table 75 & 76).

Crops/ Varieties/Cropping system

The drought tolerant varieties of fingermillet (long, medium and short duration at various dates of sowing), groundnut (TMV-2) and pigeonpea (TTB-7) were introduced during *kharif* to cope with the rainfall variability of the region. In fingermillet, long duration variety MR-1 (Fig. 62) recorded higher grain yield of 2593 kg/ha, followed by medium duration variety GPU-28 (Fig. 63) recorded 25.56 /ha. The short duration variety GPU-48 (Fig. 64) recorded grain yield of 2480 kg/ha) was

Fig. 59 : Conservation furrow between rows of Pigeonpea in Fingermillet + Pigeonpea (8:2) system

Fig. 60 : Conservation furrow between rows of Pigeonpea in Groundnut + Pigeonpea (8:2) system

Fig. 61 : Fingermillet + *Akkadi* Crops (Farmers practice)

Table 75 : *In-situ* moisture conservation in Fingermillet + pigeonpea (8:2) intercropping system

Treatments	Rain fall (mm)	Yield (q/ha)		Yield (kg/ha) GEY	Straw yield (kg/ha)	RWUE (kg/ha/mm)	Net returns (Rs/ha)	BC ratio
		FM	PP					
Fingemillet + Pigeon pea (8:2) with conservation furrow	621	2667	417	3861	541	6.2	31534	3.10
Farmers' practice	477	1894	-	-	59.40	3.97	11989	1.90

FM - Fingermillet, PP- Pigeonpea

Table 76 : *In-situ* moisture conservation in groundnut + pigeonpea intercropping system

Treatments	Rain fall (mm)	Crop duration (days)	Yield (kg/ha)		Yield (kg/ha) Y1 + Y2 (PEY)	RWUE (kg/ha/mm)	Net returns (Rs/ha)	BC ratio
			GN	PP				
Groundnut + Pigeon pea (8:2) with conservation furrow	577	188	792	913	2072	3.59	40506	3.32
Farmers' practice	574	190	547	-	-	0.95	816	1.06

GN - Groundnut, PP – Pigeonpea

observed. Variety MR-1 recorded highest net returns (Rs. 19634) and B:C ratio (2.48), whereas rainwater use efficiency (12.9 kg/ha/mm) was highest in GPU-28 variety. If sowing is delayed, GPU-48 is suitable for real time contingent cropping (Table 77).

Transplanted fingermillet (Fig. 65) recorded higher grain yield (2623 kg/ha), harvest index (0.55), RWUE (8.01 kg/ha/mm), net returns (Rs. 19393/ha) and BC ratio (2.46) as compared to direct sown fingermillet (Fig. 66) which recorded the grain yield of 2172 kg/ha with a BC ratio of 2.09. In case of delayed onset of monsoon transplanting of long duration fingermillet variety MR-1 is found to be more remunerative than direct seeding. Percentage of increase in yield of transplanting over direct seeding of MR-1 was 2076 kg/ha (Table 78).

Pigeonpea (BRG-1) + cowpea (IT-38956-1), recorded grain equivalent yield (1383 kg/ha), RWUE (2.38 kg/ha/mm), net returns (Rs. 35805/ha) and BC ratio (3.84). While the farmers' practice of pigeon pea (sole crop) gave pigeon pea grain yield (476 kg/ha), RWUE (0.82 kg/ha/mm), net returns (Rs. 4060/ha) and BC ratio (1.32). While in pigeon pea (BRG-1) + fieldbean (HA-4) intercropping system recorded pigeonpea seed equivalent yield (1224 kg/ha), RWUE (2.07 kg/ha/mm), net returns (Rs. 30028/ha) and

Fig. 62 : Fingermillet cv. MR-1 (Long duration)

Fig. 63 : Fingermillet cv. GPU-28 (Medium duration)

Fig. 64 : Fingermillet cv. GPU-48 (Short duration)

Table 77 : Performance of various drought tolerant varieties of fingermillet under early and mid season drought situation

Treatments	DOS	Rainfall (mm)	Crop duration (Days)	Yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha/mm)	Net returns (Rs/ha)	BC ratio
MR-1 (Long duration)	22-07-2011	466	113	2593	5876	5.59	19634	2.48
GPU-28 (Medium duration)	05-08-2011	270	85	2556	5960	11.47	19281	2.45
GPU-48 (Short duration)	21-09-2011	192	65	248	298	12.9	16226	2.2

Fig. 65 : Transplanted after 21 days (MR-1)

Fig. 66 : Direct sown with long duration variety (MR-1)

Table 78 : Performance of transplanted fingermillet under delayed onset of monsoon situation

Treatments	DOS	Rainfall (mm)	Crop duration (Days)	Yield (kg/ha)	Straw yield (kg/ha)	RWUE (kg/ha/mm)	Net returns (Rs/ha)	BC ratio
Direct sown (MR-1)	22-07-2011	425	106	2172	5235	5.56	14519	2.09
Transplanted (MR-1)	08-08-2011	366	102	2623	5126	8.01	19393	2.46

BC ratio (3.35). While the farmers' practice of pigeonpea (sole crop) gave pigeonpea grain yield (4.53 kg/ha), RWUE (0.78 kg/ha/mm), net returns (Rs. 3055/ha) and BC ratio (1.24) (Table 79).

Yield and economics as influenced by micronutrient application in fingermillet (MR-1) + pigeonpea (TTB-7) in 8:2 intercropping system with 100% recommended dose of fertilizer + 12.5 kg/ha of $ZnSO_4$ + bio-fertilizer recorded maximum grain equivalent yield (4371 kg/ha), harvest index (0.71), RWUE (7.01 kg/ha/mm), net returns (Rs.37694/ha) and BC ratio (3.52). While the farmers' practice of fingermillet + Akkadi (fodder sorghum) gave fingermillet yield (1894 kg/ha), harvest index (0.32), RWUE (3.97 kg/ha/mm), net returns (Rs. 11,989/ha) with BC ratio (1.90). Percentage of increase in yield over control was 52.01 (Table 80).

Yield and economics as influenced by micronutrient application in groundnut (TMV-2) + pigeon pea (TTB-7) in 8:2 intercropping system (Fig. 67) with 100% recommended dose of fertilizer + 12.5 kg/ha of $ZnSO_4$ + 10 kg/ha of borax + bio-fertilizer recorded maximum pod equivalent yield (1897 kg/ha), RWUE (3.31 kg/ha/mm), net returns (Rs. 35621/ha), BC ratio (3.04) and LER (3.14) While the farmers' practice of groundnut (sole crop) gave groundnut pod yield (683 kg/ha), RWUE (1.19 kg/ha/mm), net returns (Rs. 4624/ha), BC ratio (1.32) and LER (1.00). Percentage of increase in yield over control was 77.75 (Table 81).

Table 79 : Performance of pigeonpea based intercropping systems under early and mid season drought situation

Treatments	Yield (kg/ha)		Duration of Crop	Yield (kg/ha) Y1 + Y2 (GEY)	RWUE (kg/ha/mm)	Net returns (Rs/ha)	BC ratio
	PP	CP/FB					
Pigeonpea + cowpea (1:1)	1212	200	189	1383	2.38	35805	3.84
Farmers' practice	476	-	188	-	0.82	4060	1.32
Pigeonpea + Fieldbean (1:1)	842	416	198	1224	2.07	30028	3.35
Farmers' practice	453	-	188	-	0.78	3055	1.24

Rainfall : 582 mm PP - Pigeonpea; CP - Cowpea; FB - Fieldbean

Table 80 : Yield and economic as influenced by micronutrient application in fingermillet + pigeonpea (8:2) intercropping system

Treatments	Yield (kg/ha)		Crop duration (days)	Yield (kg/ha) GEY	Straw yield (q/ha)	RWUE (kg/ha/mm)	Net returns (Rs/ha)	BC ratio
	FM	PP						
Fingemillet + pigeonpea (8:2) with $ZnSO_4$ (12.5 kg/ha)	2879	379	212	4371	6144	7.01	37694	3.52
Farmers' practice	1894	-	121	-	5940	3.97	11989	1.90

FM - Fingermillet, PP - Pigeonpea

Table 81 : Yield and economics as influenced by micronutrient application in groundnut + pigeonpea (8:2) intercropping system

Treatments	Yield (kg/ha)		Duration of Crop 1 & 2	Yield (kg/ha) Y1 + Y2 (PEY)	RWUE (kg/ha/ mm)	Net returns (Rs/ha)	BC ratio
	GN	PP					
Groundnut + Pigeonpea (8:2) with $ZnSO_4$ (12.5 kg/ha) and Borax (10 kg/ha)	606	921	185	1897	3.31	35621	3.04
Farmers' practice	683	-	185	-	1.19	4624	1.32

Rainfall :574 mm GN - Groundnut, PP - Pigeonpea

Fig. 67 : Groundnut + pigeonpea (8:2) with ZnSO4 and Borax

Rainwater harvesting and recycling

A farm pond size of 12 m x 12 m top-width, 6m x 6m bottom-width, 3 m depth, slide slope 1:1, lining material LDPE (Low density poly ethylene) 400 m, soil and Cement (8:1) lining and storage capacity of 250 m^3 was dug (Fig. 68) for efficient rainwater harvesting and recycling. The existing farm pond(s) in the village is of size 180 m^3 was renovated. The stored water in the farm pond during this year was efficiently utilized for supplementary irrigation/ life saving irrigation for plantation and vegetable crops during dry spells.

Fig. 68 : Lining of old farm pond

Two farm ponds were constructed including excavation of pit and lining of pond in the farmers' fields, namely Sri Ravikumar, Mudalapalya and Sri. Krishnappa, Chikkaputtaiahnapalya.

Weekly data	Depth of water in pond (mm)
Farm pond-1: Ravikumar, Mudalapalya	1250
Farm pond-2: Krishnappa, C.P. Palya	1800
Farm pond-3: Chikkegowda, C.P. Palya	240
Farm pond-4: Gubbanna, C.M. Halli	2650

Renovation of farm ponds

Renovation of two old farm ponds were completed (only lining of pond) in the farm of Sri Chikkegowda, chikkaputtaiahnapalya and Sri Gubbanna, chikkamaranahalli

Two bore-wells were selected to take up recharge experiment at Hosapalya (Tirumalegowda) and Kalipalya (Marinanjaiah) (Fig. 69). Missing of water/ gap was observed at 6 min. interval of time, 13.5 lpm was recorded before recharging of bore well and the total cost for the recharging of bore wells was Rs.27000/-.

Fig. 69 : Adoption of ground water recharge

Excavation of pits completed and filling of materials is completed for two bore wells, by following UAS (B) technology as indicated in Fig. 70a, b, c

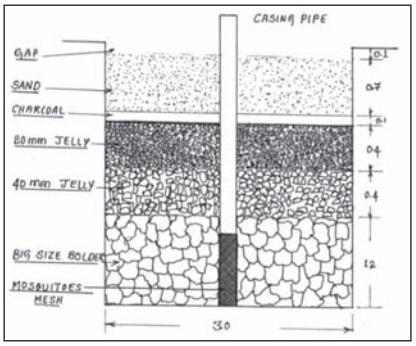

Fig. 70a : Schematic diagram of bore well recharging with different layers (all the units are in meter)

Fig. 70b : Excavated for Bore well recharge

Fig. 70c : Filling boulder layer

Timely operations through Custom Hiring Center

A custom hiring center (Fig. 71) was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements made available were seed drill, disc plough, spike tooth harrow, sprayers, cultivators and hand weeders during *kharif* season were in greater demand. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period.

Following were the tools/implements/machineries provided to the farmers through Custom Hiring Centre (Table 82) and the implements hired by the farmers are shown in Table 83.

Fig. 71 : Custom hiring centre, Bangalore

Table 82 : Implements made available at custom hiring centre, Chikkamaranahalli village

Hand tools	Bullock Drawn	Tractor Drawn	Electric/ diesel operated
Improved Sickles (50)	KM Plough (3)	Disc plough (2)	Winnower (2)
Hand weeders (20)	Multi Furrow opener(4)	MB Plough (1)	Water Lifting Pump(2)
Groundnut (5) decorticator	Modified seed drill (6)	Cultivator (2)	Chaff cutter (1)
Maize Sheller (5)		Post Hole digger (1)	
Hand ridger (2)		Rotovator (1)	
Knapsack sprayer (5)		Leveler (1)	
		Spike tooth Harrow(2)	

*Figures in parenthesis are number available in Custom hiring Centre

Note: Tools in greater demand are improved sickles, sprayers, cultivators, disc plough, seed drills, hand tools.

Table 83 : Implements hired by the farmers

Name of the Tools/ Implements/Machineries	No. of times hired by farmers
Cultivator	6
Spike tooth Harrow	6
Modified seed drill	8
Hand weeders	8
Knapsack sprayer	40
Disc plough	5
MB Plough	3
Improved Sickles	19
KM Plough	2
Post Hole digger	3
Leveler	5
Water Lifting Pump	6

Alternate land use and eco-system services

Mango based agri-horti system with pigeonpea and field bean crops were demonstrated in farmers' fields. These interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies.

Pigeonpea (BRG-1) + filed bean (HA-4) intercropping system (Fig. 72) recorded seed equivalent yield (1383 kg/ha), RWUE (2.38) kg/ha/mm), net returns (Rs. 35605/ha) and B:C ratio (3.78). While the farmers' practice of pigeonpea (sole crop) gave pigeonpea grain yield (453 kg/ha), RWUE (0.78 kg/ha/mm), net returns (Rs. 3055/ha) and BC ratio (1.24). Whereas, mango is young and yet to yield. Percentage of increase in yield over control was 86.53 (Table 84).

Fig. 72 : Pigeonpea + filed bean in mango orchard

Table 84 : Yield and economics of pigeonpea + fieldbean (1:1) intercropping in mango based agrihorti system

Treatments	Yield (kg/ha)		Duration of Crop 1 & 2	Yield (kg/ha) Y1+Y2 GEY	RWUE (kg/ha/mm)	Gross returns (Rs/ha) from C1 & C2	Net returns (Rs/ha)	BC ratio
	PP	FB						
Intercropping of Pigeonpea & fieldbean (1:1) in Mango	842	416	189	1383	2.38	48405	35605	3.78
Farmers' Practice	453	-	188	-	0.78	15855	3055	1.24

Rainfall : 582 mm * Mango - young plants, PP - Pigeonpea, FB - Fieldbean

1.4. Pearlmillet Based Production System

1.4.1 AGRA

a. Agro-ecological setting

Agra is located in Northern Plain (and Central Highlands) including, Ganga-Yamuna Doab and Rajasthan Upland (*AESR 4.1)* and South western semi aried agroclimatic zone in Uttar Pradesh. The climate is hot semi-arid. Annual rainfall is 669 mm. Length of growing period is 90-120 days.

b. On-station experiments

At Agra, the onset of monsoon was on 27th June, which was one week early than normal onset. A rainfall of 634 mm was received during cropping period as against normal of 899.6 mm in 2011. An excess rainfall of 14.7% was received during July month only. However, a deficit rainfall of 76.7, 20.4, 24 and 75.3% was received during June, August, September and October months, respectively. Further, no rain was received during November and December months (Fig. 73).

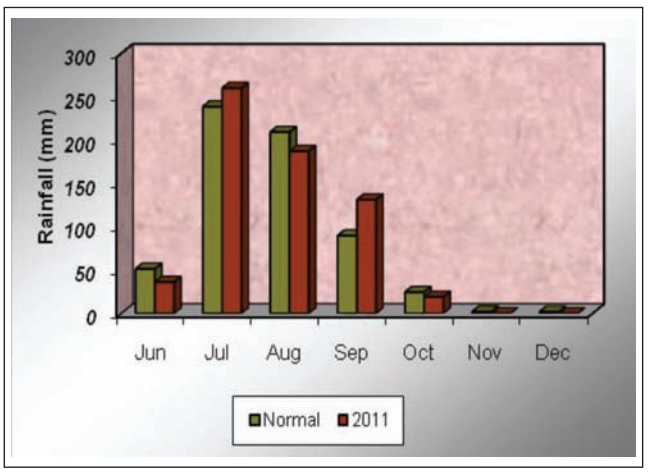

Fig. 73 : Normal and actual (2011) monthly rainfall at Agra

c. On-farm experiments

Village profile

The program is implemented by AICRPDA Center, Agra, Nagla Dulhe Khan village and Faziyatpura block, Kheragarh Tehsil in Agra District, Uttar Pradesh. Nagla Dulhe Khan is situated in the South-western part of Agra district and lies between 26°55' to 26°56' North latitude and 77° 40' 30"to77°42'30" East longitude. The total cultivated area is 981 ha, out of which 878 ha is rainfed. The mean annual rainfall was 665 mm with seasonal rainfall of 589 mm during *kharif* (June-September). The major soil types are sandy loam to loamy sand. The major rainfed crops during *kharif* are pearlmillet, pigeonpea, greengram, blackgram, sesame and sorghum for fodder purpose and during *rabi* are mustard, barley, chickpea, lentil, linseed under rainfed conditions. The number of small, medium and large farmers are 326, 256 and 37 respectively. The groundwater table is 40 m. which is saline. The source of irrigation is bore well covering 30% of cultivated area.

Climate Variability in General

In general, the climate in this agro-climatic zone is semi arid, heat waves during summer (March to mid June). The south-west monsoon contributes 88%, north-east monsoon 9.0% and summer 2.5% of the total annual average rainfall of 665 mm. Historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon 30.5% of the average rainfall. The onset (South-west) of monsoon is 1st week of July during 27th SMW. The temperature reaches 48° C in June and as low as up to 1.0° C or below during January. Heat wave during summer and cold wave during winter were common along with frost or foggy conditions during crucial crop growth stages. The dry spells during crop season had been experienced, for the past 10 years, in July, August and September respectively at germination, vegetative and grain formation stage of the major rainfed crops. The onset of monsoon was normal (1st week of July). Out of 12 years study, early season drought or weak monsoon was experienced in 6 times i.e. 2001, 2002, 2004, 2007, 2009 and 2010, in July and mid season drought was recorded in 2000, 2001, 2003, 2005, 2006 in the August at vegetative stage and 2000 and late season drought was experienced during September in 2004, 2005, 2006 and 2007.

The onset of monsoon was during 20th June to July 15 in the last 38 years out of 40 years and withdrawal of monsoon was during 10th September and 25th September in 29 years out of 40 years and in 8 years, withdrawal was noticed after 25th September and too early withdrawal registered in three years i.e. 1979 (11th Aug.), 2001 (26th Aug.) and 2006 (16th August), The soil moisture status was deficit during vegetative stages of major rainfed crops. The extreme events like unusual and high intensity rainfall in short span were experienced during *kharif* and *rabi* seasons. The area also had been experiencing other

extreme events i.e. high temperature after withdrawal of monsoon, adversely affecting germination of mustard yield. Foggy weather was also experienced during *rabi* season.

Experienced weather conditions during the year 2011-12

The village received 635.9 mm which was excess of 46.8 mm compared to normal 589 m during south-west monsoon (*kharif*). The onset of monsoon was 27th June which was one week earlier than normal period and withdrawal was also one week earlier (15th Sept). Dry spell during crop growth period was not experienced. The intense rainfall events were experienced on 27th June (78.4 mm) which was also considered as the date of onset of monsoon followed by 61.2 mm occurred on 6th August, on the basis of prevailing conditions**.** Two intense rainfall events viz. 78.4 mm (27th June) and 61.2 mm (6th August) occured during the season. Post monsoon rains were not recorded while winter rains recorded in January month (42.0 mm).

Interventions

The major on-farm interventions included land configuration, crops/varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring centre and alternate land use systems. These interventions covered an area of 71 ha in179 farmers' fields.

Real time contingency crop planning

Crops /hybrids/varieties / Cropping system

Three hybrids/varieties of pearlmillet were evaluated on farmers fields. Pro-agro-9444 rerecorded higher mean seed yield (2933 kg/ha) as compared to JK-778 (2611 kg/ha) and JKBH-26 (2500 kg/ha). Highest grain yield (3125 kg/ha) RWUE (6.83 kg/ha/mm) and BC ratio (3.02) was obtained in pearlimillet. There was no dry spell experienced during the crop season (Table 85).

Two sesame varieties were evaluated in 10 farmers' fields. TKG-55 gave higher mean seed yield of 660 kg/ha

Table 85 : Performance of pearlmillet varieties under normal onset of monsoon

Variety	Farmer's name	Yield (kg/ha)	Harvest index	RWUE (kg/ha/mm)	Cost of Cultivation	Gross returns (Rs/ha)	BC ratio
Proagro-9444	Sr. Mahendra Singh	3125	34.5	6.83	12083	36555	3.02
Proagro-9444	Sr. Rajvir Singh	2875	33.3	6.28	12083	33925	2.80
Proagro-9444	Sr. Raghuvir Singh	3000	34.0	6.55	12083	35220	2.91
Proagro-9444	Sr. Gurdayal Singh	3000	34.2	6.55	12083	35160	2.90
Proagro-9444	Sr. Shyamvir Singh	2750	34.2	6.00	12083	32230	2.66
Proagro-9444	Sr. Ramvir Singh	2850	33.8	6.22	12083	33805	2.79
Mean		**2933.3**	**34.0**	**6.40**	**12083**	**34482**	**2.85**
JKBH-26	Sr. Hari Singh	2375	32.3	5.18	12033	28255	2.35
JKBH-26	Sr. Janak Singh	2500	33.9	5.46	12033	29375	2.44
JKBH-26	Sr. Bhoop Singh	2625	33.6	5.73	12033	30915	2.56
JKBH-26	Sr. Bhojram Jatav	2250	30.7	4.91	12033	27110	2.25
JKBH-26	Sr. Achal Singh	2375	31.2	5.18	12033	28495	2.36
JKBH-26	Sr. Ramji Lal	2625	31.9	5.73	12033	31325	2.60
JKBH-26	Sr. Uday Singh	2500	31.8	5.46	12033	29850	2.48
JKBH-26	Sr. Badlooram Jatav	2750	33.4	6.00	12033	32420	2.69
Mean		**2500**	**32.3**	**5.46**	**12033**	**29718**	**2.47**
JK-778	Sr. Makhan Singh	2750	33.0	6.00	12068	32530	2.69
JK-778	Sr. Ram Singh	2850	32.9	6.22	12068	33140	2.74
JK-778	Sr. Manoj Parmar	2800	33.2	6.11	12068	33070	2.74
JK-778	Sr. Bachchu Singh	2500	31.5	5.46	12068	29920	2.48
JK-778	Sr. Pappu Kushwaha	2250	31.2	4.91	12068	270090	2.23
JK-778	Sr. Bhagirath	2520	31.7	5.50	12068	29870	2.47
Mean		**2611.6**	**32.2**	**5.70**	**12068**	**39022**	**2.56**

as compared to RT-46 (505 kh/ha). Highest sesame yield of 750 kg/ha was recorded with RWUE of (1.63 kg/ha/mm) and BC ratio (4.66). The variation in yield was attributed to the management of resources (Table 86).

Six demonstrations on two clusterbean varieties were conducted. RGC-1002 proved to be higher yielder gave mean yield of 1327 kg ha^{-1} as compared to mean yield recorded under RGC-1025 (1183 kg ha^{-1}). Highest yield of clusterbean (1380 kg/ha) was obtained with RWUE of (3.10 kg/ha/mm) and BC ratio of (2.74) (Table 87).

Six varieties of mustard on 20 farmers' fields were evaluated. Rohini was considered as farmers choice. Higher mean yield of 2095 kg ha^{-1} was registered under Bio-902 followed by Urvashi (1965 kg ha^{-1}) as compared to Rohini (1746 kg ha^{-1}). The mean increase in yield of Bio-902 was 16.3% over to Rohini. (Table 88).

Nine demonstrations on two chickpea varieties viz. Avrodhi and Uday were conducted. The mean yield of 2038 kg/ha was realized with cv. Avrodhi with BC ratio of 6.26 (Table 89).

Table 86 : On-farm performance of sesame varieties under normal onset of monsoon

Variety	Farmer's name	Yield (kg/ha)	Harvest index	RWUE (kg/ha/mm)	Cost of Cultivation	Gross returns (Rs/ha)	BC ratio
TKG-55	Sh Sobran Singh	750	19.92	1.63	11253	52500	4.66
TKG-55	Sh Shiv Das Jatav	625	19.92	1.36	11253	43750	3.88
TKG-55	Sh Rajendra Singh	500	19.84	1.09	11253	35000	3.11
TKG-55	Sh Virender SinghJatav	625	19.53	1.36	11253	43750	3.88
TKG-55	Sh Pradeep Kumar	800	19.84	1.74	11253	56000	4.97
Mean		**660**	**19.81**	**1.44**	**11253**	**46200**	**4.10**
RT-46	Sh Vishvendra Singh	375	19.38	0.82	11127	26250	2.35
RT-46	Sh Narayan Singh	400	19.23	0.87	11127	28000	2.51
RT-46	Sh Shailendra Singh	550	19.68	1.20	11127	38500	3.46
RT-46	Sh Sahab Singh	620	18.73	1.35	11127	43400	3.90
RT-46	Sh Achal Singh	580	20.00	1.26	11127	40600	3.64
Mean		**505**	**19.40**	**1.10**	**11127**	**35350**	**3.17**

Table 87 : On-farm performance of clusterbean varieties under normal onset of monsoon

Crop	Variety	Farmer's name	Yield (kg/ha)	Harvest index	RWUE (kg/ha/mm)	Cost of Cultivation	Gross returns (Rs/ha)	BC ratio
Clusterbean	**RGC-1002**	Sh. Basudev Sharma	1350	25.9	2.94	11041	29700	2.68
	RGC-1002	Munna Kushwaha	1380	25.5	3.01	11041	30360	2.74
	RGC-1002	Keshav Kushwaha	1250	25.0	2.73	11041	27500	2.41
	Mean		**1327**	**25.4**	**2.89**	**11041**	**29187**	**2.61**
	RGC-1025	Sh Pradeep Paarmar	1050	23.7	2.29	11041	23100	2.08
	RGC-1025	Nihal Singh	1200	25.7	2.62	11041	27060	2.44
	RGC-1025	Pushpendra Singh	1300	25.6	2.83	11041	28600	2.57
	Mean		**1183**	**25.0**	**2.58**	**11041**	**26253**	**2.36**

Table 88 : Performance of mustard varieties under conserved moisture condition

Variety	Farmer's name	Yield (kg/ha)	Harvest index	Cost of Cultivation	Gross returns (Rs/ha)	BC ratio
Bio-902	Sh. Radhey Shyam	2120	21.3	13501	88360	6.54
Bio-902	Sh. Bhoop Singh	2050	22.7	13501	85020	6.29
Bio-902	Sh. Ramvir Parmar	2070	20.8	13501	86520	6.40
Bio-902	Sh. Shyamvir Singh	2000	21.5	13501	83280	6.16
Bio-902	Sh. Gurdayal Singh	2110	23.5	13501	87170	6.45
Bio-902	Sh. Anil Parmar	2220	23.0	13501	91790	6.80
Mean		**2095**	**20.95**	**13501**	**87023**	**6.44**
Urvashi	Sh. Santosh Baghel	2070	22.7	13501	85700	6.34
Urvashi	Sh. Manvendra Singh	1920	22.0	13501	79770	5.90
Urvashi	Sh. Sunny Parmar	2020	21.9	13501	83950	6.21
Urvashi	Sh. Mahendra Singh	1850	21.5	13501	77050	5.70
Mean		**1965**	**22.02**	**13501**	**81617**	**6.04**
Lakshmi	Sh. Hari Singh	1900	21.9	13501	78960	5.80
Lakshmi	Sh. Satendra Singh	1680	21.6	13501	69920	5.17
Lakshmi	Sh. Bijendra Singh	1660	20.6	13501	69471	5.14
Mean		**1746.6**	**21.40**	**13501**	**72784**	**5.37**
Rohini	Sh Pradeep Parmar	1870	22.2	13501	77580	5.74
Rohini	Sh Guddu Singh	1970	21.4	13501	82070	6.07
Rohini	Sh Sanjay Singh	1560	21.2	13501	65050	4.81
Mean		**1800.0**	**21.6**	**13501**	**74900**	**5.54**
NRCDR-2	Sh. Omvir Sharma	1900	21.7	13501	79020	5.85
NRCDR-2	Sh. Jagdish Singh	1970	21.3	13501	82100	6.08
NRCDR-2	Sh. Ajay Singh	1970	21.9	13501	81850	6.06
Mean		**1946.6**	**21.63**	**13501**	**80990**	**5.99**
NRCHB-101	Sh. Virendra Singh	1850	20.8	13501	77330	5.72

Table 89 : Performance of chickpea varieties on farmers' fields

Variety	Farmer's name	Yield (kg/ha)	Harvest index	Cost of Cultivation	Gross returns (Rs/ha)	BC ratio
Avrodhi	Sh. Peetam Singh	2150	48.0	14034	92620	6.59
Avrodhi	Sh. Keshav Singh	1870	42.5	14034	81070	5.77
Avrodhi	Sh. Rajvir Singh	1920	46.6	14034	82840	5.90
Avrodhi	Sh. Makhan Singh	2200	45.4	14034	95040	6.77
Avrodhi	Sh. Prem Singh	2050	48.1	14034	88310	6.29
Mean		**2038**	**46.1**	**14034**	**87976**	**6.26**
Uday	Sh. Dharmendra Singh	1450	40.0	14034	63070	4.63
Uday	Sh. Vishvendra	1760	46.5	14034	75940	5.57
Uday	Sh. Shailendra Singh	1540	43.5	14034	66680	4.89
Uday	Sh. Pankaj Singh	1800	48.1	14034	77540	5.69
Mean		**1637.5**	**44.5**	**14034**	**70807**	**5.19**

Strip cropping of pearlmillet + sesame and clusterbean each were demonstrated. Maximum pearlmillet equivalent yield of 3908 kg ha^{-1} was registered in pearlmillet + sesame cropping system compared to sole pearlmillet system (Table 90).

Chickpea was inter cropped (5:1) with mustard and was demonstrated at five locations. Mustard + chickpea (1:5) system performed better, gave higher chickpea yield and on an average, 34.0% higher BC ratio (7.38) was obtained as compared to sole chickpea (5.50) (Table 91).

Greengram - mustard sequence system performed better compared to sole mustard (Table 92).

Four demonstrations were conducted on sesbania - mustard system. Mustard yield varied from 2257 to 2355 kg ha^{-1} under green manuring system while in farmers' practices it varied from 1375 to 16201 kg ha^{-1}. Mustard grown after green manuring in *kharif* recorded grain yield of 2305 kg ha^{-1} with BC ratio of 6.26 as compared to yield of 1496 kg ha^{-1} and BC ratio of 4.92 respectively recorded in farmers' practices (Table 93).

Table 90 : Productivity and profitability of pearlmillet + sesame stripcropping system

Farmer's name	Yield (kg/ha)	RWUE (kg/ha/mm)	Pearl millet equivalent Yield (kg/ha)	Harvest Index	Cost of Cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Sanjay Singh	1620+300	8.22	3763	54.22	11668	36877	25208	3.16
Anil Parmar	1560+320	8.40	3846	55.39	11668	37691	26023	3.23
Mahendra Singh	1640+340	8.90	4069	57.63	11668	39876	28208	3.42
Manoj Sharma	1600+330	8.64	3957	56.53	11668	38779	27711	3.32
Mean	**1605+322.5**	**8.54**	**3908.75**	**55.94**	11668	**38305**	**26787**	**3.28**
Sanjay Singh	1875.0	4.10	1875.0	31.05	10440	22537	12097	2.15
Anil Parmar	1770.5	3.87	1770.5	30.58	10440	21365	10925	2.04
Mahendra Singh	1690.5	3.70	1690.5	31.34	10440	20269	9829	1.94
Manoj Sharma	1950.0	4.26	1950.0	30.95	10440	23458	13018	2.24
Mean	**1821.5**	**3.98**	**1821.5**	**30.98**	10440	**21907**	**11467**	**2.090**

Table 91 : Performance of chickpea in sole and inter cropping system

Farmer's name	Mustard + chickpea Yield (kg/ha)	Chickpea equivalent (kg/ha)	Harvest index	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Sh Shiv Kumar	1780+680	2395	44.40	13954	100590	86636	7.21
Nanig Ram	1800+700	2433	42.37	13954	102186	88232	7.32
Sunny parmar	1840+740	2510	45.04	13954	105420	91466	7.55
Smt. Mohandevi	1820+720	2471	43.86	13954	103782	89828	7.44
Mean	**1810+710**	**2452.25**	**43.91**	**13954**	**102994**	**89040**	**7.38**
Sole Chickpea							
Sh Shiv Kumar	1470	1470	37.73	11860	61740	49880	5.20
Nanig Ram	1620	1620	37.03	11860	68040	56180	5.73
Sunny Parmar	1440	1440	36.36	11860	60480	48620	5.10
Smt. Mohandevi	1690	1690	37.59	11860	70980	59120	5.98
Mean	**1555**	**1555**	**37.17**	**11860**	**65310**	**65310**	**5.50**

Table 92 : Performance of greengram – mustard sequence cropping system

Variety	Farmer's name	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Greengram (*Kharif*)								
K-851	Natthi Lal	870		1.90	9942	39150	29208	3.94
K-851	RajaramSingh	823		1.80	9942	37035	27093	3.72
K-851	Pappu	915		2.00	9942	41175	31233	4.14
K-851	Prithvi Singh	845		1.84	9942	38025	28083	3.82
Mean		**863.25**		**1.88**	9942	**38846**	**28904**	3.90
Mustard (*Rabi*)								
Bio-902	Natthi Lal	1900	21.0	45.23	10445	79320	68875	7.59
Bio-902	RajaramSingh	1850	21.5	44.05	10445	77050	66605	7.37
Bio-902	Pappu	1780	21.2	42.38	10445	74220	63775	7.10
Bio-902	Prithvi Singh	1960	21.9	46.66	10445	81450	71005	7.79
Mean		**1872.5**	**21.4**	**44.58**	10445	**78010**	**62740**	**7.46**
Greengram –Mustard Crop sequence								
K-851+ Bio-902	Natthi Lal	2930			20387	111340	90953	5.46
K-851+ Bio-902	RajaramSingh	2825			20387	107350	86963	5.26
K-851+ Bio-902	Pappu	2863			20387	108794	88407	5.34
K-851+ Bio-902	Prithvi Singh	2960			20387	112480	92093	5.52
Mean		**2894.5**			20387	**109991**	**89604**	**5.39**
Farmers' practice								
Bio-902	Natthi Lal	1670	24.36	39.76	12574	68644	56070	5.45
Bio-902	RajaramSingh	1540	24.04	36.66	12574	63386	50812	5.04
Bio-902	Pappu	1625	24.10	38.70	12574	66868	54294	5.32
Bio-902	Prithvi Singh	1475	23.80	35.12	12574	60770	48196	4.83
Mean		1577.5	24.07	37.56	12574	64917	52343	5.16

Table 93 : Performance of mustard with green manuring

Farmers' name	Yield (kg/ha)	Harvest Index	Cost Cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Banwari Lal	2355	22.27	15270	97709	82439	6.40
Pooran Singh	2282	22.52	15270	94566	79296	6.19
Gordhan Singh	2328	21.93	15270	96751	81481	6.33
Sher Singh	2257	22.02	15270	93755	78485	6.13
Mean	**2305.5**	**22.18**	**15270**	**95695**	**80425**	**6.26**
Farmers practice (without green manuring)						
Banwari Lal	1620	23.80	12574	66744	54170	5.31
Pooran Singh	1460	21.74	12574	60736	48162	4.83
Gordhan Singh	1530	22.99	12574	63265	50691	5.03
Sher Singh	1375	21.74	12574	57200	44626	4.54
Mean	**1496.25**	**22.56**	**12574**	**61986**	**49412**	**4.92**

To demonstrate efficient use the of N in split applications in pearlmillet, 15 demonstrations were conducted. The grain yield of pearlmillet varied from 2760 to 3270 kg/ha under split N application, while it varied from 1930 to 2275 kg/ha under farmers' practice (Table 94).

To demonstrate the impact of application of potassium fertilizer on mustard, fifteen demonstrations were conducted on farmers' fields. Mustard seed yield varied from 2100 to 2380 kg/ha with a mean value of 2265 kg/ha with K application. (Table 95).

Table 94 : Performance of pearlmillet with N split application

Farmers name	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross income (Rs/ha)	Net returns (Rs/ha)	BC ratio
Split application (-N)							
Sri Nihal Singh	3250	34.2	7.10	12183	38090	25907	3.12
Prithvi Singh	3120	33.8	6.81	12183	36686	24503	3.01
Sultan Singh	3240	34.5	7.08	12183	37902	25719	3.11
Smt. Shakuntala	3270	34.6	7.14	12183	38226	26043	3.13
Sri Prem Chand	2980	31.7	6.51	12183	33350	21167	2.73
Gordhan Baghel	3150	32.2	6.88	12183	37480	25297	3.07
Pooran Singh	3080	34.4	6.72	12183	36034	23851	2.95
Rajaram	2850	31.2	6.22	12183	34200	22017	2.81
Rajeev Sharma	2800	32.2	6.11	12183	33320	21137	2.73
Anar Singh	2760	32.0	6.02	12183	32898	20715	2.70
Amar Singh	2880	32.2	6.29	12183	34264	22081	2.81
Peetam Singh	2850	32.2	6.22	12183	33910	21727	2.78
Pawan Parmar	3120	34.2	6.81	12183	36566	24383	3.00
Pankaj Singh	3160	33.9	6.90	12183	37128	24945	3.05
Nanak Ram	3000	34.2	6.55	12183	35160	22977	2.88
	3034	**33.16**	**6.62**	**12183**	**35681**	**23498**	**2.92**
Farmers' Practice (No Split application of N)							
Sri Nihal Singh	2275	31.74	4.96	11883	27186	15303	2.28
Prithvi Singh	2050	31.54	4.47	11883	24538	12655	2.06
Sultan Singh	2230	31.05	4.87	11883	26804	14921	2.25
Smt. Shakuntala	2056	31.34	4.49	11883	24651	12768	2.07
Sri Prem Chand	2170	30.76	4.74	11883	26148	14265	2.20
Gordhan Baghel	2090	31.54	4.56	11883	25017	13134	2.10
Pooran Singh	1966	31.64	4.29	11883	23513	11630	1.97
Rajaram	1930	31.44	4.21	11883	23121	11238	1.94
Rajeev Sharma	2025	30.58	4.42	11883	24442	12559	2.05
Anar Singh	1985	31.34	4.33	11883	23800	11917	2.00
Amar Singh	2110	30.95	4.60	11883	25383	13500	2.13
Peetam Singh	1940	31.05	4.23	11883	23319	11436	1.96
Pawan Parmar	2070	31.44	4.52	11883	24798	12915	2.08
Pankaj Singh	2100	31.64	4.58	11883	25116	13233	2.11
Nanak Ram	2010	30.86	4.39	11883	24200	12317	2.03
Mean	**2067.13**	**31.26**	**4.51**	**11883**	**24802**	**12919**	**2.08**

Table 95 : Performance mustard with K application

Farmers name	Yield (kg/ha)	Harvest Index	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Sri Ramji lal	2200	21.5	14460	91630	77170	6.33
Kaptan Singh	2320	22.2	14460	95500	81040	6.60
Amar Singh	2380	22.4	14460	97520	83060	6.74
Ramnivas Singh	2250	22.0	14460	93480	79020	6.46
Keshav Sharma	2230	22.2	14460	92540	78080	6.39
Rajendra singh	2370	22.6	14460	98150	83690	6.78
Achal Singh Jatav	2180	23.7	14460	91010	76550	6.29
Manoj Sharma	2300	23.6	14460	95150	80690	6.58
Prempal	2280	21.6	14460	94890	80430	6.56
Pratap Singh	2200	21.6	14460	91560	77100	6.33
Pohapi Valmiki	2310	22.8	14460	95220	80760	6.58
Pawan Kumar	2310	22.9	14460	97190	82730	6.72
Ram Singh Tomar	2100	21.2	14460	87570	73110	6.05
Kalua	2280	21.8	14460	94800	80340	6.55
Manoj Tomar	2270	21.9	14460	94320	79860	6.52
Mean	**2265.3**	**22.26**	**14460**	**94035**	**79575**	**6.50**
Sri Ramji lal	1620	22.22	12574	67230	54656	5.35
Kaptan Singh	1540	22.62	12574	63786	51212	5.07
Amar Singh	1460	21.74	12574	60736	48162	4.83
Ramnivas Singh	1390	21.73	12574	57824	45250	4.60
Keshav Sharma	1475	23.52	12574	60844	48270	4.84
Rajendra singh	1560	23.47	12574	64365	51791	5.12
Achal Singh Jatav	1710	23.80	12574	70754	57880	5.63
Manoj Sharma	1625	23.64	12574	66998	54424	5.33
Prempal	1485	22.22	12574	61627	49053	4.90
Pratap Singh	1525	22.57	12574	63180	50606	5.02
Pohapi Valmiki	1495	22.72	12574	61893	49319	4.92
Pawan Kumar	1625	23.00	12574	67191	54617	5.34
Ram Singh Tomar	1640	22.93	12574	67830	55256	5.39
Kalua	1390	21.74	12574	57824	45250	4.60
Manoj Tomar	1675	23.30	12574	69162	56588	5.50
	1547.66	**22.74**	**12574**	**64083**	**51489**	**5.10**

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient utilization

Land configuration

The *in situ* moisture conservation practices included ridge sowing, compartmental bunding, deep ploughig in summer and tillage after each effective rainfall enhanced *in situ* moisture conservation. This resulted in mitigating dry spell and enhanced the crop yield of pearlmillet by 41 to 50% and mustard by 41 to 44% as compared to farmers' practice.

Ten demonstrations were conducted on sowing of pearlmillet on shoulder of ridge using ridger seeder. Sowing with ridger seeder produced about 41% higher yield (2934 kg/ha) compared to broadcasting method(2071 kg/ha). Improvement in yield with ridger seeder was due to enhanced moisture conservation and safe disposal of excess rain water. Higher BC ratio of 2.82 was also registered under ridge sowing system which was 30% more than recorded with broadcasting of sowing system (Table 96).

Ten demonstrations were conducted on *in-situ* moisture conservation with compartmental bunding which resulted in more conservation of moisture and enhanced crop yield by 50% and rain water use efficiency by 54% compared to farmers practice (4.04) (Table 97).

Demonstrations were conducted on tillage after each effective rainfall in mustard on 10 farmers fields. Yield of mustard increaed from 2210 to 2373 kg/ha under improved practice (tillage after each effective rainfall) with mean yield of 2303 kg/ha, while the mean yield with farmers practices was 1589 kg/ha.

Efficient energy use and management

A custom hire centre was established in the village with need based agriculture implement and custom hiring committee was formed to provide facilities.

Table 96 : Performance in of pearlmillet with ridge and furrow system of sowing

Treatments	Variety	Farmers name	Yield (kg/ha)	Harvest index	RWUE (kg/ha/ mm)	Cost culti-vation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Ridge and furrow system	**JKBH-26**	Natthi Baghel	3150	34.1	6.88	12333	36950	24617	2.99
	JKBH-26	Gordhan Singh	2980	33.6	6.50	12333	35074	22491	2.84
	JKBH-26	Gulab Singh	3100	34.2	6.77	12333	36330	23997	2.94
	JKBH-26	Banwari Baghel	3050	34.5	6.66	12333	35680	23347	2.89
	JKBH-26	Rakesh Bhaghel	2900	32.2	6.33	12333	34510	22177	2.79
	JKBH-26	Har Prasad	3000	33.6	6.55	12333	36890	24557	2.99
	JKBH-26	Rajan Singh	2980	31.8	6.50	12333	35574	23241	2.88
	JKBH-26	Prem Chand	2780	31.2	6.07	12333	33354	21021	2.70
	JKBH-26	Jagganath	2750	31.7	6.00	12333	32880	20547	2.66
	JKBH-26	Sher Singh	2650	30.7	5.78	12333	31930	19597	2.58
	Mean		**2934**	**32.76**	**6.40**	**12333**	**34917**	**22559**	**2.82**
Broad Casting	**JKBH-26**	Natthi Baghel	2118	30.67	4.62	11633	25543	13910	2.19
	JKBH-26	Gordhan Singh	2186	30.03	4.77	11633	26516	14883	2.28
	JKBH-26	Gulab Singh	2052	28.73	4.48	11633	25198	13565	2.16
	JKBH-26	Banwari Baghel	2212	31.05	4.83	11633	26588	14955	2.28
	JKBH-26	Rakesh Bhaghel	2150	30.77	4.70	11633	25907	14274	2.22
	JKBH-26	Har Prasad	2020	29.41	4.41	11633	24644	13011	2.11
	JKBH-26	Rajan Singh	1950	28.08	4.25	11633	24102	12469	2.07
	JKBH-26	Prem Chand	2046	28.40	4.47	11633	25206	13573	2.16
	JKBH-26	Jagganath	2080	28.81	4.54	11633	25521	13888	2.19
	JKBH-26	Sher Singh	1902	28.24	4.15	11633	23470	11838	2.01
	Mean		**2071.6**	**29.42**	**4.52**	**11633**	**25269.5**	**13637**	**2.16**

Table 97 : Performance of pearlmilet with compartmental bunding

Treatments	Variety	Farmers name	Yield (kg/ha)	Harvest index	RWUE (kg/ha/ mm)	Cost culti-vation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Compart-mental Bunding	**JKBH-26**	Sri Nattharam	3100	33.9	6.77	12333	36420	24087	2.95
	JKBH-26	Indra Singh	2950	31.2	6.44	12333	35400	23067	2.87
	JKBH-26	Ramveer Singh	3050	33.9	6.66	12333	35830	23497	2.90
	JKBH-26	Sarnam Singh	3020	34.2	6.60	12333	35386	23053	2.86
	JKBH-26	Feran Singh	2800	33.0	6.11	12333	33120	20787	2.68
	JKBH-26	Gurudatt Sharma	2950	33.2	6.44	12333	34830	22497	2.82
	JKBH-26	Bijendra Singh	2780	31.7	6.07	12333	33214	20881	2.69
	JKBH-26	Sunny Parmar	2650	31.6	5.79	12333	31690	19357	2.56
	JKBH-26	Lalbahadur Singh	2680	31.2	5.84	12333	32154	19821	2.60
	JKBH-26	Pratap Singh	2500	32.0	5.46	12333	29800	17467	2.41
	Mean		**2848**	**32.59**	**6.22**	**12333**	**33784**	**21451**	**2.73**
Without compart-mental Bunding	**JKBH-26**	Sri Nattharam	2062	30.76	4.50	11733	24847	13114	2.12
	JKBH-26	Indra Singh	1995	28.17	4.35	11733	24638	12905	2.10
	JKBH-26	Ramveer Singh	1890	27.17	4.12	11733	23587	11854	2.01
	JKBH-26	Sarnam Singh	1680	26.66	3.67	11733	21084	9351	1.80
	JKBH-26	Feran Singh	1755	27.77	3.83	11733	21762	10029	1.85
	JKBH-26	Gurudatt Sharma	1942	28.40	4.24	11733	23925	12192	2.04
	JKBH-26	Bijendra Singh	1870	29.85	4.08	11733	22720	10987	1.94
	JKBH-26	Sunny Parmar	1765	28.90	3.85	11733	21621	9888	1.84
	JKBH-26	Lalbahadur Singh	1640	27.93	3.58	11733	20303	8570	1.73
	JKBH-26	Pratap Singh	1932	28.40	4.22	11733	23803	12070	2.03
	Mean		1853.1	28.40	4.04	11733	22829	11096	1.94

1.4.2 HISAR

a. Agro-ecological setting

Hisar is located in western Plain, Kachchh and part of Kathiawar peninsula, Rajasthan Bagar, north Gujarat Plain and Southwestern Punjab plain (*AESR 2.3)* and Southwestern dry zone in Haryana The climate is hot arid. Annual rainfall is 411 mm. Annual potential evapo-transpiration is 769mm.

b. On-station experiments

At Hisar, the onset of monsoon was normal i.e. 4th July. A rainfall of 275.6 mm was received during cropping period as against normal of 345 mm in 2011. An excess rainfall of 151% was received during September month only over the normal rainfall. However, a deficit rainfall of 41.1, 35.6, 46.2% was observed during June, July and August months, respectively. Further, no rain was received during October, November and December months (Fig. 74).

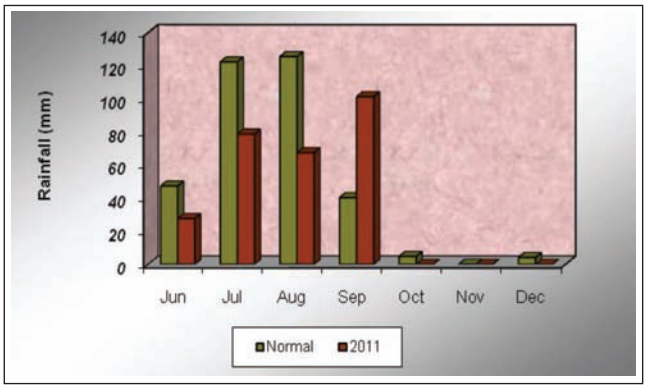

Fig. 74 : Normal and actual (2011) monthly rainfall at Tahkepal Village

Alternate land use and ecosystem services

Tree based agri-silvi-pasture system with *kharif* crops were demonstrated on station. Agroforestry, agro-horti and other carbon capture systems help in both adaption and mitigation. Hence, these interventions were made to educate farmers that climate change as both short-term and long-term strategies.

c. On-farm experiments

Village profile

Balawas

The program is implemented by AICRPDA Centre, Hisar in Balawas village, Tehsil Hisar in Hisar district, Haryana. The total cultivated area is 800 ha out of which 560 ha is rainfed. The mean annual rainfall is 350 mm with seasonal rainfall of 320 mm during *kharif* (June-September). The major soil types are loamy sand to sandy loam. The major crops in *kharif* under rainfed are pearlmillet, clusterbean, greengram, mothbean, sesame and castor and *rabi* are mustard, chickpea barley and rape seed. The number of small, marginal, medium and large farmers is 138, 22, 2 and 4 respectively. The ground water table is 25 m. The source of irrigation is canal + tube well covering 30 % of cultivated area.

Charnod

The program is being implemented in the village Charnod Tehsil, Hisar in district Hisar (Haryana). The total cultivated area is 418 ha out of which 251 ha is rainfed. The mean annual rainfall is 360 mm with seasonal rainfall of 325 mm during *kharif* (June-September). The major soil types are loamy sand to sandy loam. The major crops in *kharif* under rainfed are pearlmillet, clusterbean, greengram, mothbean, sesame and castor and *rabi* are mustard, chickpea barley and rapeseed. The number of small, marginal, medium and large farmers is 132, 10, 22 and 14, respectively. The ground water table is 20 m. The source of irrigation is canal and tube well covering 60% of cultivated area.

Budhshelli

The program is being implemented at the villages Buhshelli Tehsil Siwani in district Bhiwani (Haryana). The total cultivated area is 985 ha out of which 886 ha is rainfed. The mean annual rainfall is 280 mm with seasonal rainfall of 220 mm during *kharif* (June-September). The major soil types are loamy sand to sandy loam. The major crops in *kharif* under rainfed are pearl millet, clusterbean, greengram, mothbean, sesame and castor and *rabi* are mustard, chickpea barley and rape seed. The number of small, marginal, medium and large farmers is 285, 22, 88 and 5 respectively. The ground water table is 35 m. The source of irrigation is tubewell covering 10% of cultivated area.

Climate Variability in General

In general the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 85-90 %, and winter 10-15% of the total annual average rainfall of 280-320 mm. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon

every fourth year is a drought year. The onset (south-west) of monsoon is during 26 SMW. The dry spells during crop season were experienced for the past 10/15 years July, August and October and at seedling, vegetative, and reproductive stages of the major rainfed crops. The soil moisture status was deficit during vegetative and reproductive stages of major rainfed crops. The maximum/ minimum temperature during crop season was almost static but frost occurs during *rabi* in December and January (-0.112/-0.071° C) past 10 years. The extreme events like unusual and high intensity rainfall in short span had been increasing during *kharif*. The area had also been experiencing other extreme events like frost and cold wave. There had also been considerable shift in rainfall pattern with late onset (29/30 SMW) and early withdrawal (35/ 36 SMW) and sowing window to 31 or 32 SMW of the dominant rainfed crops viz. pearlmillet, clusterbean, blackgram and castor.

Experienced weather conditions during the year (2011-12)

The village Balawas, Charnond and Buddhshelly received 196.5, 215.8 and 267 mm, respectively, which was deficit of 123.5, 109.2 mm in village Balawas and Charnond respectively compared to normal 320 and 325 mm, respectively during south-west monsoon (*kharif*) whereas in village Buddhshelly the excess of 47 mm was observed against the normal rainfall of 220 mm. The onset of monsoon was delayed by two weeks. The crops experienced dry spells at the end of August at vegetative stages of rainfed crops. During *rabi,* frost was observed during December and January which caused the reduction in mustard yield.

Interventions

The major interventions were implemented both under on-farm included land configuration, crops or varieties/ cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use systems. These interventions covered an area of 60-75 ha in 150 farmers' fields.

Land configuration

The land configuration included ridge furrow system in mustered (Fig. 75a) which facilitated runoff modulation/ improved the drainage and enhanced *in-situ* moisture conservation. This enhanced the yield and rainwater use efficiency by 18.5% compared to farmers' practice (Fig. 75b) (Table 98).

Fig. 75a : Mustard with ridge and furrow system

Fig. 75b : Mustard with flat bed system

Real time contingency crop planning

Under this component, the suitable varieties of rainfed crops viz., greengram (Muskan), clusterbean (HG 365), chickpea (C 235) and mustard (RH 30) during *kharif* and *rabi* were introduced to cope with the rainfall variability of the region. The yield increases with improved varities was 45.4% in chickpea, 29.8% in greengram, 24.6% in clusterbean and 13.4% in mustard (Table 99).

Table 98 : Performance of mustard with ridge and furrow system

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE of Improved (kg/ha/mm)	BC ratio
		Improved practice (Ridge and furrow system)	Farmers' practice			
Mustard	RH-30	1065.7	899.3	18.5	379	2.3

Table 99 : Performance of improved varities of various crops

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved practice	Farmers' practice		
Clusterbean	HG 365	961.3	771.3	24.6	3.1
Greengram	Muskan	747.3	575.9	29.8	1.8
Chickpea	C 235	638.2	438.8	45.4	1.6
Mustard	RH 30	993.3	875.8	13.4	2.1

For mitigating the long dry spells during crop growth stages, weeding and moisture conservation was done using wheel hand hoe (Fig. 76a) against traditional *kasola* in pearlmillet (Fig. 76b), chickpea and mustard (Table 100).

For enhancing the yields at farmers' fields, another intervention of advance application of fertilizers in mustard at withdrawal of rains for *rabi* crops was introduced (Table 101).

To cope with long dry spell during *kharif* season, strip cropping of pearlmillet with legume was introduced (Fig. 77a, 77b) (Table 102). The improved variety of chickpea i.e. C 235 was introduced which gave 2.2% more yield than HC 1 (Fig. 78a, 78b) (Table 103).

Fig. 76a : *In-situ* moisture conservation practice with wheel hand hoe

Fig. 76b : Farmers' practice (using *kasola*)

Table 100 : In-situ moisture conservation with weading and interculture during long dry spells

Crop	Variety	Yield (kg/ha)		BC ratio
		Improved practice	Farmers' practice	
Pearlmillet	HHB 67 (Improved)	1685.2	1734.5	1.5
Chickpea	C 235	685.8	701.5	1.8
Mustard	RH 30	985	1010	2.2

Improved practice – Weeding and moisture conservation with wheel hand hoe; **Farmers' practice** – Using Kasola

Table 101 : Performance of mustard with advanced fertilizer application

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved practice	Farmers' practice		
Mustard	RH 30	1327.2	1167.3	13.7	3.1

Fig. 77a : Pearlmillet + legume intercropping

Fig. 77b : Sole pearlmillet

Table 102 : Performance of Pearlmillet + legume strip cropping

Crop	Variety	Equivalent Yield (kg/ha)		% increase in yield	BC ratio
		Improved practice (Pearlmillet + legume)	Farmers' practice (Sole pearlmillet)		
Pearlmillet	HHB 67 improved	2617.3	1763.2	48.4	2.0

Table 103 : Performance of improved chickpea varieties

Crop	Variety	Yield (kg/ha)	% increase in yield	BC ratio
Chickpea	C235	610	2.2	1.4
	HC 1	597		

Fig. 78a : Chickpea cv. C235

Fig. 78b : Chichpea cv. HC-1

Rainwater harvesting and recycling

A water harvesting structure (Tanke) with 3.6 m diameter and 4.75 m depth with capacity 52 m^3 was used for efficient rainwater harvesting and recycling in Budhshelly Village (Fig. 79) . In this village, a proposal of roof top water harvesting from the village school and connecting the same to the village pond has been received. Further action shall be taken in due course of time. The existing farm pond(s) in the village Balawas of size 45'x30'x8' was renovated. The stored water in the farm pond during this year was efficiently utilized for drinking of farm animals.

Fig. 79 : Rainwater harvesting in tanke, Budhshelly village

Timely operations through Custom Hiring Center

A custom hiring center was established in the villages Budhshelly, Charnond and Balawas with need based implements viz. ridger seeder, seed cum fertilizer drill, spray pumps and wheel hand hoes were made available and a Custom Hiring Committee was constituted to facilitate activities smoothly. The committee decided the rates for custom hiring of implements and to undertake any repair and maintenance of machines out of the funds generated. Even in irrigated parts of the dryland area, the farmers preferred the use of ridger seeder due to saving of irrigation water.

1.4.3. SK NAGAR

a. Agro-ecological setting

Saradar Krishinagar is located in Western Plain, Kachchh and part of Kathiawar peninsula, Rajasthan Bagar, north Gujarat Plain and southwestern Punjab plain (AESR 2.3). Annual rainfall is 782 mm.

b. On-station experiments

At S.K. Nagar, the onset of monsoon was on 7th July, which was delayed by 10 days. A rainfall of 915.3 mm was received in 34 rainy days during cropping period as against normal of 806 mm in 2011. An excess rainfall of 21.6 and 150.8 per cent was received during August and September, respectively over the normal rainfall. However, a deficit rainfall was observed during June and July to the extent of 100 and 19.4 per cent, respectively. Further, no rain was received during October, November and December months (Fig. 80).

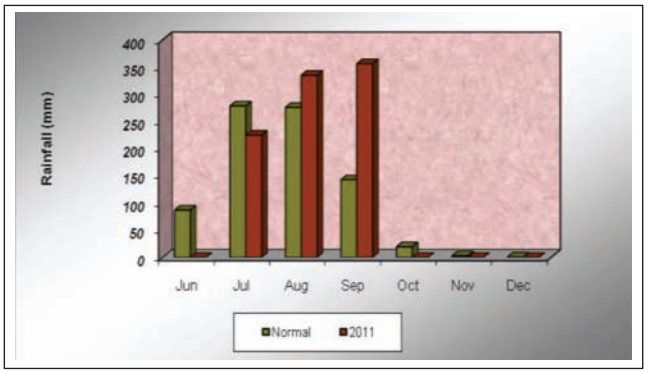

Fig. 80 : Normal and actual (2011) monthly rainfall at SK Nagar

Real time contingency crop planning

There was deficit rainfall during June and July. Among the improved varieties /hybrids of crops evaluated viz. castor,pearlmillet, greengram, clusterbean and mothbean, GHB 558 of pearlmillet gave high RWUE of 1.33. Among different hybrids of castor, GCH 7 produced higher seed yield (1005 kg/ha), gross returns (Rs. 38375/ha), B:C ratio (4.51) and RWUE (1.1 kg/ha mm) compared to other hybrids. However, Mung 4, Guar 2 and Mothbean 2 performed better under this region under 10 days delayed onset of monsoon. Further, among different intercropping systems, Castor (GCH 7) + greengram gave higher B:C ratio (5.04) and compared to other intercroping systems viz. castor + sesame and castor + Karingada under delayed onset of monsoon to cope with the rainfall variability (Table 104).

Table 104 : Performance of *kharif* crops under early season drought

Crops	Yield (kg/ha)				Castor equivalent yield	Cost of Cultivation	Gross income (Rs/ha)	BC ratio	RWUE (kg/ha mm)
	Seed	Straw/ stalk	Seed	Straw/ stalk					
Pearlmillet (GHB 538)	1105	3464	-	-	-	7500	16356	2.18	1.21
Pearlmillet (GHB 558)	1220	3535	-	-	-	7500	17624	2.35	1.33
Castor (GCH 2)	640	550	-	-	-	8500	24439	2.88	0.70
Castor (GCH 4)	750	650	-	-	-	8500	28640	3.37	0.82
Castor (GCH 5)	973	810	-	-	-	8500	37152	4.37	1.06
Castor (GCH 7)	1005	850	-	-	-	8500	38375	4.51	1.10
Greengram (Mung 3)	305	950	0	0	-	4800	11185	2.33	0.33
Greengram (Mung 4)	410	1130	0	0	-	4800	14815	3.09	0.45
Clusterbean (Guar 1)	295	712	0	0	-	4900	28709	5.86	0.32
Clusterbean (Guar 2)	375	810	0	0	-	4900	36352	7.42	0.41
Moth bean 1	390	750	0	0	-	4900	18675	3.81	0.43
Moth bean 2	325	560	0	0	-	4900	15465	3.16	0.36
Castor (GCH 7) + Greengram (GM 4)	875	675	252	755	1125	8500	42862	5.04	0.96
Castor (GCH 7)+sesame	710	505	175	225	949	8500	36157	4.25	0.78
Castor (GHB 558)+Karingada in third row of pearlmillet	950	3110	72	0	459	7000	4636	0.66	1.04

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre,SKNagar in Kalimati/Dholiya village, taluka Amirgadh, Banaskantha district and Chandank village, taluka Becharaji in Mehsana district, Gujarat. The total cultivated area is 652.91 (Kalimati/Dholiya) and 448.0 ha (Chandanki) out of which 322.91 ha and 423.0 ha (Chandanki) is rainfed. The mean annual rainfall is 1028.8 mm (Kalimati/Dholiya) and 1110.3 mm (Chandanki) with seasonal rainfall of 1028.8 mm (Kalimati/Dholiya) and 1110.3 mm (Chandanki) during kharif (July-September). The major soil types are sandy loam and clay. The major rainfed crops during *kharif* are pearlmillet, greengram, castor, cotton, blackgram, sorghum, clusterbean and maize and during *rabi* are cumin etc. The number of small, marginal, medium and large farmers are 83, 49, 75 and 39 of Kalimati/Dholiya, while 60, 15, 37 and 31 of Chandanki, respectively. The source of irrigation is well, tube well, canal, check dam and farm ponds covering 51.05 % Kalimati/Dholiya and 5.58 % Chandanki of cultivated area.

Climate Variability in General

In general, the climate in this agro-climatic zone is *semi-arid*. The south-west monsoon contributes 94 %, north-east monsoon 4 % and summer 2 % of the total annual average rainfall of 613 mm. The historical rainfall data (of 30 years) indicated that there was variability in rainfall during south-west monsoon. The onset (south-west) of monsoon was during 26 SMW. The dry spells during crop season were experienced, for the past 15 years, during August and September and at vegetative to reproductive stages of the major rainfed crops. The onset of the monsoon had been shifting from 26 SMW (June) to 27 SMW (July). The soil moisture status was deficit during vegetative, reproductive and maturity stages of major rainfed crops. The data on maximum/minimum temperature during crop season viz. *kharif* T_{max}. increasing (0.011°C) and no increase in *rabi* season, while T_{min} increasing at the rate of 0.018 and 0.021 °C per year in *kharif* and *rabi* season, respectively, of past 10 years. The extreme events like unusual and high intensity rainfall in short span were increasing in July and August during *kharif* season. The area was also experiencing other extreme events like floods, heat wave and cold wave. There had

been considerable shift in rainfall pattern and uneven distribution with shift in sowing window 27 to 28 SMWs of the crops pearlmillet, greengram, sorghum, clusterbean, maize, castor, cotton etc.

Experienced weather conditions during the year (2011-12)

In the villages rainfall of Kalimati/ Dholiya and Chandanki received 1028.8 and 1110.3 mm which were excess of 136.8 mm and 334.3 mm compared to normal 892 and 776 mm during south-west monsoon (*kharif*) (Fig. 81). The onset of monsoon was delayed (9th July and 8th July *i.e.* 28 and 27 SMW). The crops experienced dry spells during germination/ maturity stages from 1st September to 30th September. The intense rainfall events were experienced in Kalimati/Dholiya 190 mm on 10 August and 151 mm on 12 September and in Chandanki 116 mm

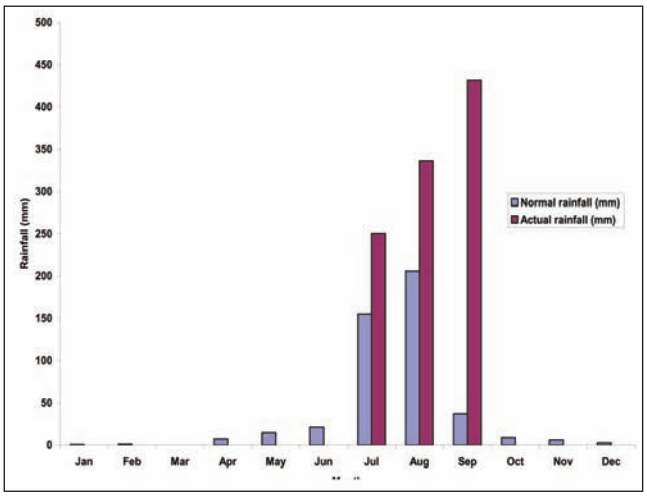

Fig. 81 : Normal and actual (2011) monthly rainfall at Kalimati

on 22 September in *kharif* season. These events impacted the stand/ performance of pearl millet, maize and pulses crops.

Interventions

The major interventions were implemented both under on-farm, broadly included crops or varieties, cropping system, rainwater harvesting and recycling, timely operations through custom hiring center. These interventions covered an area of Kalimati/Dholiya 90.65 and Chandanki 70.82 ha on 224 and 175 farmers' fields respectively.

Crops/ Varieties/Cropping system

Under this component, the improved varieties of rainfed crops viz., pearlmillet, clusterbean, castor, maize, greengram, blackgram (Fig. 82a to 82f) and improved cropping systems viz., castor + greengram and Bt cotton + blackgram were introduced (Fig. 83a, 83b, 83c) to cope with the rainfall variability of the region. The yield increase was upto 284.6 per cent compared to local variety (Table 105).

Rainwater management (*In-situ* and *ex-situ*)

The land configuration included ridge furrow system and compartment bunding and compared with flatbed system in pearlmillet (Fig. 84, 85) which facilitated runoff modulation/improved the drainage and enhanced *in situ* and *ex situ* moisture conservation. This resulted in mitigating dry spell and enhanced the yield of pearlmillet and castor and rainwater use efficiency compared to farmers practice, and the yield increase was by 66.3 per cent in pearlmillet and 38.5 per cent in castor with compartment bunding and 52.6 per cent in castor with ridge and furrow system (Table 106).

The supplemental irrigation from the harvested rainwater in farm pond (Fig. 86a, 86b) to castor and cumin (Fig. 87a, 87b) increased the yields up to 41.7 per cent and 43.2 per cent respectively.

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements Roto till drill, Strip till drill and Zero till drill gave higher output energy and crop yield compared to normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period. Mechanization in greengram resulted in high energy output,net returns and BC ratio (Table 107).

Table 105 : Performance of improved varities of *kharif* rainfed crops and intercropping system under terminal drougt situation

Crop	Variety	Yield (kg/ha)		% increase	BC ratio
		Improved practice	Farmers' practice		
Kalimati/Dholiya					
Pearlmillet	GHB 558	1492	1015	46.99	2.87
Clusterbean	GG 2	306	228	34.21	6.62
Castor	GCH 7	1266	753	68.12	5.86
Maize	HQPM 1	2482	979	153.52	4.51
Greengram	Guj. Mung 4	478	373	28.15	3.56
Blackgram	Guj. Urad 1	519	352	47.44	3.60
Bt Cotton	Bijdhan 2	2096	545	284.58	8.22
Castor + greengram	GCH 7+ Guj. Mung 4	1340	794	68.76	5.26
Bt cotton + blackgram	Bt cotton (Bijdhan 2) + Black gram	2405	2003	20.06	8.20
Chandanki					
Pearlmillet	GHB 558	1471	1019	44.35	2.84
Castor	GCH 7	1248	745	67.51	5.72
Cotton	G cot 21	799	503	58.84	3.66
Castor + greengram	GCH 7+ Guj. Mung 4	1084	718	50.97	5.56

Fig. 82a : Pearl millet (GHB 558)

Fig. 82b : Cluster bean (Guj. Guar 2)

Fig. 82c : Castor GCH 7

Fig. 82d : Maize (HQPM 1)

Fig. 82e : Greengram (GM 4)

Fig. 82f : Blackgram (GU 1)

Fig. 82 (a to f) : Performance of improved varities *kharif* rainfed crops in Kalimati / Dholiya village

Fig. 83a : Cotton (GC 21)

Fig. 83b : Castor GCH-7

Fig. 83c : Castor + greengram intercropping

Fig. 83 (a to c) : Performance of improved varities of rainfed *kharif* crops and greengram intercropping systems in Chandanki village

Table 106 : Effect of *in situ* moisture conservation practices on yield of crops

Crop	Variety	Yield (kg/ha)		% increase	RWUE (kg/ha-mm)	BC ratio
		Compartment bunding	Farmers' practice			
Pearlmillet	GHB 558	1545	929	66.30	1.50	2.80
Castor	GCH 7	1280	924	38.52	1.15	5.90
		Ridge & Furrow	**Farmers' practice**			
Castor	GCH 7	1291	846	52.60	1.25	5.92
		Supplemental irrigation	**Farmers' practice**			
Castor	GCH 7	1280	903	41.74	1.15	5.57
Cumin	GC 4	616	430	43.25	0.55	8.90

Fig. 84 : Performance of pearlmillet with compartment bunding

Fig. 85 : Peralmillet -Flat bed system

Fig. 86a : Farm pond for irrigation

Fig. 86b : Supplemental irrigation in castor

Fig. 87a : Cumin (GC 4) with supplemental irrigation

Fig. 87b : Cumin -No supplemental irrigation

Table 107 : Performance of improved seed drills in greengram

Implement	Crop	Variety	Energy (MJ) for improved implement		Net returns (Rs/ha)	BC ratio
			Input	Output		
Roto till drill	Greengram	Guj. Mung 4	5585.71	41796	14742	2.97
Strip till drill			5585.71	40418	14089	2.88
Zero till drill			5585.71	36749	11957	2.59
Local practices			6242.96	23442	5537	1.79

1.5. Sorghum Based Production System

1.5.1. BIJAPUR

a. Agro-ecological setting

Bijapur is located in Karnataka Plateau (AESR 3) and Northen dry zone in Karnataka The climate is hot arid. Potential evapo-transpiration is 622 mm. The rainfall is 594 mm. The length of growing period is 90-120 days.

b. On-station experiments

At Bijapur, the onset of monsoon was during second week of June. There was no delay in onset of monsoon but long dry spells were experienced during cropping season. A rainfall of 453 mm was received during cropping period against normal of 522.8 mm in 2011 (Fig. 88). There was an excess rainfall of 105.3 and 45.5 per cent over normal rainfall during July and September, respectively. However, 47.1, 51.6, 26.4, 100 and 100 per cent deficit rainfall was observed during June, September, October, November and December months, respectively over normal rainfall. Totally there were 37 rain days during cropping period.

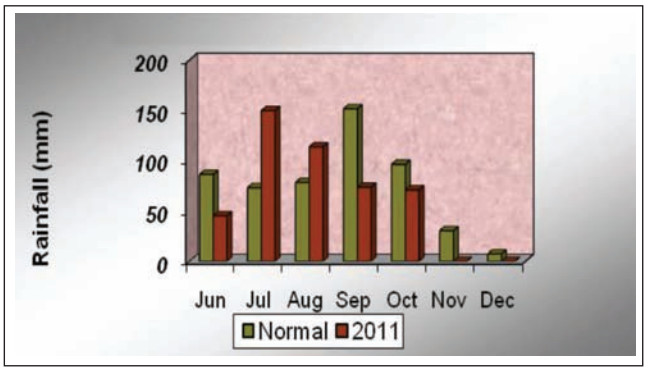

Fig. 88 : Normal and actual (2011) monthly rainfall at Bijapur

Alternate land use systems

At on-station, in the existing alternate land use systems viz. sapota, simaruba, aonla and tamarind based agri-horti systems in medium deep black soils with intercrops like chickpea, were demonstrated to educate the farmers that climate change need to be tackled both short term and long term strategies. The component crops included fig, drumstick and chickpea. Among these systems, Simaruba + guava + chickpea gave higher gross returns (Rs. 77308/ ha) (Table 108 to 110).

Table 108 : Sapota based agri-horti system in medium deep black soils

Alternate land use system	Sub plot Inter row plant	chickpea seed yield (kg/ha)	Guava yield (kg/ha)	Drum stick yield (kg/ha)	Gross income (Rs/ha)			
					Chickpea	Guava	Drumstick	Total
Sapota alone	No inter row plant	332	-	-	10614	0	0	10614
	Guava	256	3667	-	8183	36667	0	44850
	Fig	265	-	-	8479	0	0	8479
	Drum stick	228	-	4667	7307	0	9333	16640
Sapota + Guava	No inter row plant	285	3000	-	9120	30000	0	39120
	Guava	273	5267	-	8747	52667	0	61413
	Fig	232	2967	-	7413	29667	0	37080
	Drum stick	217	2033	4967	6955	20333	9933	37221
Sapota + Fig	No inter row plant	273	-	-	8747	0	0	8747
	Guava	255	3533		8160	35333	0	43493
	Fig	232	-	-	7414	0	0	7414
	Drum stick	217	-	5200	6955	0	10400	17355
Sapota + Drumstick	No inter row plant	253	-	3267	8105	0	6533	14638
	Guava	255	2400	2933	8159	24000	5867	38026
	Fig	219	-	3200	7008	0	6400	13408
	Drum stick	217	-	4300	6955	0	8600	15555

Table 109 : Simaruba based agri-horti system in medium deep black soils

Alternate land use system	Sub plot Inter row plant	chickpea seed yield (kg/ha)	Guava yield (kg/ha)	Simaruba beans yield (kg/ha)	Gross income (Rs/ha)			
					Chickpea	Guava	Simaruba beans	Total
Simaruba alone	No inter row plant	266	-	486	10116	0	7292	17407
	Guava	176	6354	472	6683	63542	7083	77308
	Fig	180	-	424	6836	0	6354	13190
	Drum stick	156	-	403	5911	0	6042	11953
Simaruba + guava	No inter row plant	176	4688	330	6684	46875	4948	58507
	Guava	234	5208	319	8886	52083	4792	65761
	Fig	187	4792	299	7124	47917	4479	59520
	Drum stick	165	4271	295	6261	42708	4427	53397
Simaruba + fig	No inter row plant	197	-	375	7477	0	5625	13102
	Guava	192	5938	354	7301	59375	5313	71988
	Fig	190	-	347	7212	0	5208	12420
	Drum stick	153	-	347	5833	0	5208	11041
Simaruba + drumstick	No inter row plant	184	-	313	6994	0	4688	11681
	Guava	145	4792	285	5498	47917	4271	57685
	Fig	178	-	264	6774	0	3958	10732
	Drum stick	147	-	271	5587	0	4063	9649

Table 110 : Aonla based agri-horti system in medium deep black soils

Horticultural Components	Arable crops	Chickpea equivalent yield (kg/ha)	Custard apple yield (kg/ha)	Henna leaf yield (Kg/ha)
Aonla alone	No intrcrop	0	-	-
	Chickpea	538	-	-
	Chickpea + saflower	746	-	-
Aonla + henna	No intrcrop	0	-	195
	Chickpea	225	-	198
	Chickpea + saflower	307	-	195
Aonla + custard apple (CA)	No intrcrop	0	478	-
	Chickpea	322	385	-
	Chickpea + saflower	427	340	-
Aonla+ CA+ henna	No intrcrop	0	378	150
	Chickpea	205	403	148
	Chickpea + saflower	612	400	145

c.On-farm experiments

Village: Kavalagi

Village profile

The program is implemented by AICRPDA Centre, Bijapur in Kavalagi village, Bijapur tehsil in Bijapur district, Karnataka. The total cultivated area is 1327 ha out of which 1307 ha is rainfed. The mean annual rainfall is 594.3 mm with seasonal rainfall of 387.5 mm during *kharif* (June-September). The major soil types are shallow to medium deep black soils, shallow red soils and gravelly soils. The major crops during *kharif* under rainfed are pearlmillet, pigeonpea, greengram, groundnut, maize and during *rabi* are sorghum, chickpea, wheat, sunflower and safflower. The number of small, marginal, medium and large farmers is 144, 53, 200, 04 respectively. The ground water table is 70-90 m. The source of irrigation is open-wells and bore-wells covering 1.5% of cultivated area only.

Climate Variability in General

The climate in this agro-climatic zone is dry semi-arid. Out of the total annual average rainfall of 594.4 mm, the south-west monsoon contributes 65 %, north-east monsoon 22.5% and summer 12.5 %. The historical data (of 30 years) indicated that the variability in rainfall during south-west monsoon was manifested in delayed onset while mid season drought.

Experienced weather conditions during the year (2011-12)

The village received 382.1 mm which was *deficit by* 5.5 mm compared to normal (387.5 mm) during south-west monsoon (*kharif*) and 70.8 mm which was *deficit by* 63.2 mm compared to normal (134.0 mm) during North-East monsoon (*rabi*). The onset of monsoon was delayed by 24 days (3rd July, 2011) than the normal (9th June). The rainfed crops during *kharif* experienced dry spells during 8-30 June, 3-29 September, November and December months (Fig. 89).

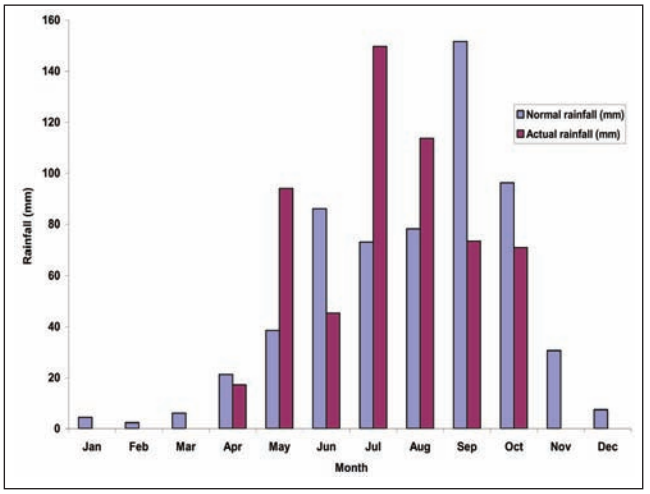

Fig. 89 : Normal and actual (2011) monthly rainfall at Kavalagi village

Interventions

The major interventions were implemented included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 36.4 ha in 47 farmers' fields.

Land configuration

The compartment bunding (4x 4 m size) was done in 30 farmers' fields covering an area of 12 ha followed by sowing of chickpea (cv. JG11) (Fig. 90a). This resulted in mitigating dry spell during vegetative and flowering stages of chickpea which resulted in enhancement of the crop yield by 63% and rainwater use efficiency by 63% compared to farmers practice (Fig. 90b) (Table 111).

Table 111 : Performance of chickpea with compartment bunding under mid season drought situation

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha/mm)		BC ratio	
		Improved practice (with Compart-ment bund)	Farmers' practice (flat sowing)		With Compart-ment bund	Without Compart-ment bund	With Compart-ment bund	Without Compart-ment bund
Chickpea	JG-11	605.8	371.25	63	8.55	5.24	2.2	1.22

Fig. 90a : Chickpea without compartment bunding

Fig. 90b : Chickpea with compartment bunding

Crops/ Varieties/Cropping system

Drought tolerant variety of chickpea i.e. JG-11 (Fig. 91a), during *rabi* was introduced to cope with the rainfall variability of the region. There was an yield enhancement of 21 % with chickpea cv JG -11 compared to local (Fig. 91b) (Table 112).

Table 112 : Performance of Chickpea (JG11) under mid season drought situation

Crop	Variety	Yield (kg/ha)		% yield increase
		Improved practice (JG11)	Farmers' practice (Local)	
Chickpea	JG-11	371	305	21

Frequent deep intercultivation during the dry spells in September, October and November facilitated better moisture conservation at flowering and reproductive stages of various crops viz. onion, pigeonpea, wheat and sorghum, enhancing the yield up to 18.6% (Table 113).

Rainwater harvesting and recycling

A farm pond size of 25 m x 13.6 m x 2.5 m with the capacity of 540 m^3 was dug for efficient rainwater harvesting and recycling. The farm pond was dug during March 2012. Further, during this summer, both open well and bore well recharge structures were constructed for recharging the groundwater.

Timely operations through Custom Hiring Centre

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. As per demand of the farmers, the improved implements for primary tillage, sowing, weeding, gave higher output (Fig. 92) energy and crop yield compared to normal implements. During the year 2011-12 only bund former and cycle weeders were extensively used by the farmers. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period. The farm implements made available at the custom hiring centre are listed below (Table 114)

Fig. 91a : Performance of Chickpea cv. JG-11

Fig. 91b : Performance of Chickpea - Local

Table 113 : Impact of *in situ* moisture conservation on yield of various crops

Crop	Yield (kg/ha)		% increase in yield
	Improved practice (Frequent deep intercultivation)	Farmers practice (Normal intercultivation)	
Onion	7.00	5.90	18.6
Pigeonpea	8.00	6.80	17.6
Wheat	5.00	4.50	11.0
Sorghum	5.00	4.38	14.2

Table 114 : Implements made available at custom hiring centre

Implements	Power source	Nos.	Purpose
Single Bottom Reversible M.B. Plough (45 hp)	Tractor drawn	1	Primary tillage
M.B. Plough	Bullock drawn	1	
Bund former	Bullock drawn	4	
Bund former (Sarayantra)	Bullock drawn	4	
Disc harrow	Tractor drawn	1	
Automatic seed-cum-fertilizer drill	Tractor drawn	1	Sowing
Automatic seed-cum-fertilizer drill (General type)	Bullock drawn	2	
Cycle fertilizer drill cum weeder	Manual	2	Weeding & Interculture
Roto Tiller (Power operated weeder)	Petrol operated		
Cycle weeders	Manual	3	
Hand ridger	Manual	2	
Twin wheel hoe	Manual	2	
Knapsak sprayers	Petrol operated	2	Plant protection equipment
Knapsak sprayers	Hand operated	2	
Improved sickles	Manual	20	Harvesting equipment
b) Groundnut digger	Tractor drawn	1	
c) Power operated cutter	Petrol operated	1	

Alternate land use

Alternate land use systems like agri-horti-systems help in both adaptation and mitigation.

At Kavalagi village, planting of tamarind in 4 ha, sapota in 2 ha, jamun in 2 ha and custard apple in 2 ha was done.

Fig. 92a : Cycle Weeder

Fig. 92b : Cycle drawn seed drill

Fig. 92a & b : Use of hired implements for various agricultural operations at Kavalagi village

1.5.2 SOLAPUR

a. Agro-ecological setting

Solapur is located in Deccan Plateau of South Western Maharashtra and North Karnataka Plateau (AESR 6.1) and scarcity zone in Maharashtra. The climate is hot semi-arid. Annual rainfall is 722 mm. The length of growing period is 90-120 days. Solapur is a rainfall shadow area and has drought occurring once in ten years. The soils are shallow and medium loamy black soils (deep clayey black soils).

b. On-station experiments

At Solapur, the onset of monsoon was during July end, which was delayed by one and half month compared to normal. A rainfall of 672.5 mm was received during cropping period against normal of 660.7 mm in 2011. There was an excess rainfall of 128.9, 31 and 44.5 per cent during July, August and October months respectively over normal rainfall. However, June, September, November and December months received a rainfall deficit of 79.4, 64.7, 100 and 100 percent, respectively over normal (Fig. 93).

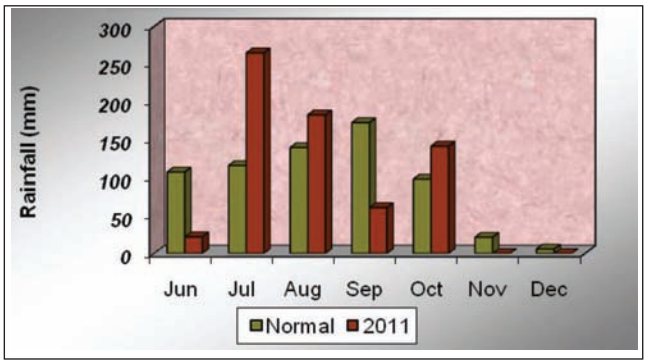

Fig. 93 : Normal and actual (2011) monthly rainfall at Solapur

Rainwater harvesting and recycling

The study on rainwater harvesting in the existing farm ponds for efficient utilization for alternate land use systems is in progress. The first extisting farm pond has the size of 30m x 20m top, 25m x 15m bottom and 2 m depth with catchment area of 3 ha and command area of 0.23 ha with capacity of 975 m^3. The water balance studies are in progress. Protective irrigation is given to custard apple, aonla, drumstick and their alley cropping like custard apple + aonla (Tables 115, 116, 117).

Table 115 : Water budgeting of farm pond

Sr. No.	MW	Rainfall, mm	Inflow, m^3	Evapo. Volume, m^3	Outflow m^3	Seepage Losses, m^3	Irrigation, m^3	Balance, m^3
1	27	181.30	1924.00	8.98	0.00	181.30	0.00	1770.84
2	28	18.80	0.00	38.14	0.00	333.37	0.00	1399.33
3	29	16.80	0.00	30.76	0.00	273.70	0.00	1094.87
4	30	19.30	0.00	37.50	0.00	186.02	8.00	863.35
5	31	49.10	0.00	31.47	0.00	177.58	1.00	654.30
6	32	6.20	0.00	31.51	0.00	165.23	0.00	457.56
7	33	23.40	56.94	28.56	0.00	76.48	0.00	411.12
8	34	98.40	285.13	25.07	0.00	29.31	0.00	644.87
9	35	82.10	480.97	24.03	0.00	30.37	0.00	1124.06
10	36	10.00	120.14	37.62	0.00	31.63	2.00	1119.33
11	37	0.00	0.00	28.84	0.00	62.92	0.60	1026.97
12	38	0.00	0.00	29.33	0.00	55.52	2.00	940.12
13	39	0.00	0.00	22.35	0.00	63.99	0.00	853.78
14	40	32.50	46.84	23.12	0.00	80.99	0.00	796.51
15	41	78.20	1172.05	27.55	0.00	88.67	0.00	1852.34
16	42	30.60	53.78	39.25	0.00	146.75	0.00	1720.12
17	43	0.20	0.00	31.56	0.00	169.71	0.00	1518.85
18	44	0.00	0.00	30.89	0.00	138.15	0.00	1349.81
19	45	0.00	0.00	26.15	0.00	170.34	0.00	1153.32
20	46	0.00	0.00	30.71	0.00	114.99	0.00	1007.62
21	47	0.00	0.00	32.48	0.00	122.92	8.00	844.22
22	48	0.00	0.00	28.87	0.00	75.89	30.60	739.46
23	49	0.00	0.00	38.15	0.00	103.50	0.00	597.81

Sr. No.	MW	Rainfall, mm	Inflow, m^3	Evapo. Volume, m^3	Outflow m^3	Seepage Losses, m^3	Irrigation, m^3	Balance, m^3
24	50	0.00	0.00	37.07	0.00	84.56	30.60	476.18
25	51	0.00	0.00	33.72	0.00	29.88	20.40	392.59
26	52	0.00	0.00	33.68	0.00	23.87	25.50	300.28
27	1	0.00	0.00	33.33	0.00	40.07	0.00	226.88
28	2	0.00	0.00	34.13	0.00	47.98	0.00	144.77
29	3	0.00	0.00	32.67	0.00	48.95	0.00	63.15
30	4	0.00	0.00	29.13	0.00	13.62	20.40	0.00
		646.90	**4139.85**	**916.60**	**0.00**	**3168.28**	**149.10**	**0.00**
	% of inflow			**22.14**	**0.00**	**76.53**	**3.60**	

Components			% of inflow
Total Inflow, cu. m	=	4139.85	100.00
Evaporation, cu. m	=	916.60	22.14
Seepage, cu. m	=	3168.28	76.53
Outflow, cu. m	=	0.00	0.00
Irrigation, cu. m	=	149.10	3.60
Balance, cu. m	=	0.00	—
% Runoff	=	11.37	—

Table 116 : Details of farm pond

Farm pond type	:	Lined (but lining damaged)
If plastic/other material, thickness of lining material stabilized, 250 gsm film (June 2007)	:	HDPE, UV
Number of farm ponds	:	1
Pond capacity, m^3	:	440 cu.m
Construction year	:	May 2003
Dimensions of farm pond	:	
Top	:	20 x 14 m.
Bottom	:	16 x 10 m.
Slope (H:V)	:	1:1
Depth	:	2 m
Catchment area under farm pond	:	3.40 ha
Command area under farm pond	:	1.0 ha.

Table 117 : Use of harvested water for supplemental irrigation for Agri-horti based farming system

Components of integrated farming system	Area	Season		
		kharif	*rabi*	summer
Agri-Horti systems (Aonla + sunflower + pigeompea)	0.30	0.30	0.30	0.30
Cowpea- *rabi* Sorghum	0.40	0.40	0.40	-
Fodder crops (maize/sorghum fodder)	0.10	0.10	0.10	
Chickpea	0.15	-	0.15	-
Livestock : 1 Buffalo + (10+1) goats	0.03	0.03	0.03	0.03
Border plantation : (Subabul + glyricidia + grasses)	0.02	0.02	0.02	0.02
Total	**1.00**	**0.85**	**1.00**	**0.35**

The water was available from 5th July 2011 to 23rd November 2011. The results indicated that, total runoff is 795.21 cu m (3.80 %), evaporation losses are 93.93 cu m (11.81 %), seepage losses are 676.88 cu m (85.12 %) and 24.40 cu m (3.07 %) of the water is used as protective irrigation to fodder and aonla (Table 118).

Table 118 : Water balance components of farm pond (second)

S. No.	MW	Rainfall, mm	Inflow, m^3	Evapo. Volume, m^3	Outflow, m^3	Seepage Losses, m^3	Irrigation, m^3	Balance, m^3
1	27	181.30	516.10	2.35	0.00	183.00	0.00	330.75
2	28	18.80	55.80	9.20	0.00	178.37	0.00	198.98
3	29	16.80	0.00	6.48	0.00	94.39	0.00	98.11
4	30	19.30	0.00	6.95	0.00	43.40	16.40	31.35
5	31	49.10	0.00	1.36	0.00	29.99	0.00	0.00
6	32	6.20	0.00	0.00	0.00	0.00	0.00	0.00
7	33	23.40	0.00	0.00	0.00	0.00	0.00	0.00
8	34	98.40	0.00	0.00	0.00	0.00	0.00	0.00
9	35	82.10	60.31	4.23	0.00	16.89	0.00	52.16
10	36	10.00	5.30	7.03	0.00	5.28	0.00	45.14
11	37	0.00	0.00	5.13	0.00	6.09	0.00	33.91
12	38	0.00	0.00	5.13	0.00	7.54	0.00	21.24
13	39	0.00	0.00	3.85	0.00	7.70	0.00	9.69
14	40	32.50	14.56	3.94	0.00	4.20	0.00	4.82
15	41	78.20	115.53	4.43	0.00	10.13	0.00	105.79
16	42	30.60	27.61	7.59	0.00	10.27	0.00	115.54
17	43	0.20	0.00	6.07	0.00	17.06	0.00	92.40
18	44	0.00	0.00	5.73	0.00	19.81	4.00	62.86
19	45	0.00	0.00	5.41	0.00	15.25	4.00	38.20
20	46	0.00	0.00	5.34	0.00	18.25	0.00	14.61
21	47	0.00	0.00	3.71	0.00	9.26	0.00	0.00
		616.10	**795.21**	**93.93**	**0.00**	**676.88**	**24.40**	
	% of inflow			**11.81**	**0.00**	**85.12**	**3.07**	

Components			% of inflow
Total Inflow, m^3	=	795.21	
Evaporation, m^3	=	93.93	11.81
Seepage, m^3	=	676.88	85.12
Outflow, m^3	=	0.00	0.00
Irrigation, m^3	=	24.40	3.07
Balance, cu. m^3	=	—	
% Runoff	=	3.80	

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Solapur in Raleras village, North Solapur Tehsil in Solapur district. The total cultivated area is 560.7 ha out of which 450 ha is rainfed. The mean annual rainfall is 761.7 mm with seasonal rainfall of 531 mm during *kharif* (June-September). The major soil types are sandy loam, loam and clay loam. The major rainfed crops during in *kharif* are sunflower, pigeon pea and blackgram and during *rabi* are sorghum and chickpea. The number of small, marginal, medium and large farmers are 52, 122, 86 and 22 respectively. The ground water table is 15 to 18 m. The source of irrigation is open dug wells and bore wells covering 15-19 % of cultivated area.

Climate Variability in General

The climate of this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 637 mm, the south-west monsoon contributes 80 % and north-east monsoon 20 %. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon 12 % deficit of the average rainfall. The onset (south-west) of monsoon is during 26 SMW and north-east monsoon is 41 SMW (October). For the past 15 years, the dry spells during crop season are experienced during August and at flowering stages of the major rainfed crops. The onset of the monsoon is normal. In the last 10 years, the maximum/minimum temperature during for both *kharif* and *rabi* flowering is increasing by 0.5^{o} C. The extreme events like unusual and high intensity rainfall in short span were increasing during *kharif* during 28 SMW (July). There had been considerable shift in rainfall pattern to (36 SMW) and sowing window.

Experienced weather conditions during the year (2011-12)

The village received 637 mm which was deficit of 85 mm compared to the normal 722 mm during south-west monsoon (*kharif*). The onset of monsoon was normal. The crops experienced dry spells during flowering stage in 44 SMW (October). The intense rainfall events were experienced during 38 SMW in September. These events impacted the performance of sunflower and pigeonpea crops.

Interventions

The major interventions included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 90 ha in 71 farmers' fields.

Land configuration

The land configuration included ridge furrow system and compartment bunding which facilitated runoff modulation/improved the drainage and enhanced in-*situ* moisture conservation (Fig. 94). This resulted in mitigating dry spell and enhanced the crop yield by 15% in sorghum and 51.9% in pigeonpea compared to farmers practice. The ridge and furrow system facilitated drainage during intense rainfall events during September resulting in better performance of pigeonpea (Table 119).

Crops/ Varieties/cropping system

The improved varieties of pigeonpea (Vipula) and sunflower (Bhanu) were introduced during *kharif* which performed better during dry spells during October (Fig. 95a, 95b). and to cope with the rainfall variability of the region (Table 120).

Table 119 : Impact of *in situ* moisture conservation on yield of sorghum and pigeonpea

Crop	Variety	Yield (kg/ha)		% increase	BC ratio
		Improved practice	Farmers' practice		
Sorghum	M-35-1	904	786	15	1:1.52
Pigeonpea	Vipula	638	420	51.9	1:1.86

Fig. 94 : Compartments bunding for *in-situ* moisture conservation in medium to deep black soils in solapur region

Table 120 : Performance of improved cv. Bhanu of Sunflower under mid season drought situation

Crop	Variety	Yield (kg/ha)		% increase	BC ratio
		Improved practice	Farmers' practice		
Pigeonpea	Vipula	259.75	168	54	1:1.74
Sunflower	Bhanu	900	780	14	1:1.48

Fig. 95a : Sunflower -Bhanu

Fig. 95b : Sunflower - Local

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements made available in the custom hiring centre are listed below (Table 121):

The improved implements gave higher output energy and crop yield compared to normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period (Table 122a, 122b).

Alternate land use and Eco-system services

Horti-pasture systems were demonstrated in farmers' fields. These interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies.

During rabi, sowing of chickpea with bullock drawn CRIDA planter and sorghum with tractor drawn grow CRIDA planter was demonstrated (Fig. 96a, 96b)

Table 121 : Improved implements made available at custom hiring centre

Particular	Qty	Particular	Qty
Aspee Bolo Hitech Sprayer	01	Baliram Plough bullock drawn	05
Aspee Marut Foot Sprayer	02	Cycle Hoe	12
Aspee Bolow Power Pump	02	Laxmi Sickle	50
Tractor operated four blade Baliram Plough	01	CRIDA 9 row tractor drawn seed cum fertilizer planter	02
Tractor operated four blade with harrow	01	CRIDA 4 row Bullock drawn seed cum fertilizer planter	01
Cultivator 9 Tyne and	01	CRIDA 3 row Bullock drawn seed cum fertilizer planter	01
5 tyne	01	FRP Rain gauge	02
Land leveller	01	Hi tech knapsack sprayer	01
Two bottom MB Plough	01	Power sprayer single piston with gun & Ele. motor	01
HTP power spray with spray gun	01	Jr. mist Blower cum duster	01

Table 122a : Field performance of tractor drawn 9 row CRIDA planter for sowing of *rabi* sorghum

Particulars	Rabi Sorghum
Date of trial	25.10.2011
Name of the farmer	Shri C.C. Kale
Location	Mardi, Tal. N. Solapur
Variety	M 35.1
Type of soil	Medium
Plot area, ha	0.40
Duration of test, h	1.15
Speed of operation, km h^{-1}	3.2
Width of operation, cm	315
Depth of seed placement, cm	6.8
Obtained seed rate, kg ha^{-1}	6.25
Recommended seed rate, kg ha^{-1}	10
Fertilizer rate, kg ha^{-1}	50:25:0
Effective field capacity ha day^{-1}	5.18
Theoretical field capacity ha day^{-1}	8.06
Field efficiency %	64.26
Plant population obtained, lakh ha^{-1}	1.24
Recommended Plant population, lakh ha^{-1}	1.111
Plant spacing obtained, cm	18.5
Recommended plant spacing, cm	20
Row spacing, cm	45
Cost of operation, a) Rs.ha^{-1}	615.25
b) Rs.h^{-1}	144.42
Yield, kg/ha	820

Table 122b : Field performance of bullock drawn CRIDA planter for sowing of chickpea

Particulars	Chickpea
Date of trial	02.11.2011
Name of the farmer	Shri Ashok Jadhav
Location	Raleras, Tal. N. Solapur
Variety	Digvijay
Type of soil	Medium
Plot area, ha	0.40
Duration of test, h	2.20
Speed of operation, km h^{-1}	2.80
Width of operation, cm	150
Depth of seed placement, cm	5.8
Obtained seed rate, kg ha^{-1}	52.0
Recommended seed rate, kg ha^{-1}	80
Fertilizer rate, kg ha^{-1}	12.5:25:0
Effective field capacity ha day^{-1}	2.34
Theoretical field capacity ha day^{-1}	3.36
Field efficiency %	69.64
Plant population obtained, lakh ha^{-1}	2.74
Recommended Plant population, lakh ha^{-1}	3.333
Plant spacing obtained, cm	12.4
Recommended plant spacing, cm	10
Row spacing, cm	30
Cost of operation, a) Rs.ha^{-1}	377.87
b) Rs.h^{-1}	88.78
Yield, kg/ha	140

Fig. 96a : Chickpea sown by Bullock Drawn CRIDA Planter

Fig. 96b : Sorghum sown by Tractor Drawn CRIDA Planter

1.5.3 JHANSI

a. Agro-ecological setting

Jhansi is located in Bundelkand uplands (AESR 4.4) and Bundelkand agro climatic zone in Uttar Pradesh. The climate is hot, moist semiarid.

b. On-farm experiments

Village profile

The program was implemented in Kadesara Kalan village Talbehat Block/Mandal/Taluk/Tehsil of Lalitpur district. The general topography is undulating to gentle slopping plain. The total cultivated area is 875.10 ha out of which 292.64 ha is rainfed. The mean annual rainfall is 1022 mm with seasonal rainfall of 684.7 mm during *kharif* (June-September). The major soil types are loamy sand, sandy loam and sandy clay loam. The major rainfed crops during *kharif* are groundnut, sesame and blackgram and during *rabi* are wheat, chickpea and mustard. The source of irrigation is ground level pumpset covering 45% of cultivated area.

Climate Variability in General

In general, the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 86.2%, north-east monsoon 5.7 % and summer 8.1% of the total annual average rainfall of 906.5 mm. The major climatic vulnerabilities of the region are delayed onset of monsoon, intermittent dry spells of >10 days, excess run off causing moisture stress during reproductive phase of *rabi* crops, terminal heat causing reduced maturity period in wheat, terminal drought at grain filling stage of wheat and migration of farmers/ laborers from village after March-April in search of employment

For the past 15 years the dry spells during crop season had been experienced, during August & September and at varying growth stages of the major rainfed crops. The onset of the monsoon is shifting (27th SMW) month July. The soil moisture status was deficit during (pod filling in Kharif crops, germination to harvesting in *rabi* crops depending on rainfall) stages of major rainfed crops. The maximum/ minimum temperature during crop season was T. max (kharif) =33.6^{o}C T. min (kharif) =23.9^{o}C & T. max (Rabi =28.7^{o}C T. min (Rabi) =10.5^{o}C past 10 years. The extreme events like unusual and high intensity rainfall in shorts pan were increasing during *kharif* and *rabi* seasons. The region was also experiencing other extreme events like Cold waves. There has been considerable shift in rainfall pattern and amount decreasing 2.0 mm/year during *kharif* season and sowing window of the dominant rainfed crops.

Experienced weather conditions during the year (2011-12)

The village received 1023 mm which was deficit of 241.9 mm compared to normal 781 mm during south-west monsoon (*kharif*). The onset of monsoon was normal. The crops experienced dry spells during wheat grain filling stage. The intense rainfall events were experienced during 25th SMW (207.4 mm) & 26th SMW (223 mm). These events had very little impact on crops which were at grain filling stage.

Interventions

The major on-farm interventions included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 27 ha approximately in 60 farmer's fields.

Land configuration

The land configuration included conservation furrow, enhanced *in-situ* moisture conservation, which resulted in mitigating dry spell and enhanced the yield of blackgram, sesamum, groundnut, maize, and rainwater use efficiency by 4.83, 15.39 & 21.20% respectively compared to farmers practice.

Real time contingency crop planning

Groundnut is the dominant crop of the district and village. The PRA of the village revealed that the farmers accepted it as dominant crop because of suitability to soil, easy marketing and high returns. The local Jhumku variety is grown in the region. It is a bunch type variety, poor yielder and susceptible to Tikka disease Pathogen (*Cercospora arachidicola*). For climate resilience, Utkarsh variety of groundnut was introduced. The variety yielded 1670 kg of pod yield and haulm yield 3204 kg/ha in comparison to 1260 kg grain and 2996 kg/ha straw for Jhumku variety. The crop recorded net grain of Rs. 66460 (Table 123) (Fig 96c).

Blackgram is also important *kharif* season crop. The farmers were more inclined towards green gram. since, the blackgram tolerates more moisture stress than green gram. The two varieties of black gram namely Azad and Uttara were introduced in the village. The Uttara variety of blackgram proved superior and produced 1336 kg seed & 2952 kg straw in comparison to Azad (1283 kg seed and 2938 kg straw/ha). The average yields of local varieties were much 1080 kg seed and 2586 kg straw (Table 124 & 125) (Fig. 96d, 96e).

Sesame is a short duration rainfed crop. It performs well in years of scanty rainfall. It is suitable for light soils, three varieties of Sesame namely; Shekhar, Type-78 and JTS-8 were evaluated for their performance under varying soil and moisture status. Among the three varieties T-78 proved better and recorded 714 kg seed (RWUE 0.88 Kg/ha/mm). This was followed by JTS-8 (662 kg seed/ha and 20.23 kg/ha/mm rain water use efficiency). The local variety yielded 410 kg seed with rain water use efficiency of 0.50 kg/ha/mm (Tables 126, 127 & 128) (Fig. 96f, 96g, 96h).

Table 123 : Performance of groundnut cv. Utkarsh

Farmers Name	Yield (kg/ha)		RWUE (kg/ha/mm)	Gross returns (Rs/ha)
	Pod	Haulm		
Sh Sahjendra Singh Bundela	1559	3810	1.91	64090
Sh Jasrath	1520	2980	1.86	60650
Sh Roshan lal	1620	3130	1.99	64525
Sh Kallu Ahirwar	1620	2940	1.99	64050
Sh Ravi Ahirwar	1610	3150	1.97	64225
Sh Ashok Yadav	1534	2950	1.88	61065
Sh Bhagirath	1620	3110	1.99	64475
Sh Hariram	1710	3450	2.10	68475
Sh Pran Singh	1898	3230	2.33	74505
Sh Sivaraj Singh	1799	2950	2.21	70340
Sh Azad	1820	3520	2.23	72500
Sh Dasrath	1750	3180	2.15	69200
Sh Ravindra Singh Bundela	1710	3310	2.10	68125
Sh Hariram	1610	3150	1.97	64225
Average (of all farmers)	**1670**	**3204**	**2.04**	**66460**

Table 124 : Performance of blackgram cv. Azad

Farmers Name	Yield (kg/ha)		Harvest Index	RWUE (kg/ha-mm)
	Seed	Straw		
Sh Sahjendra Singh Bundela	1329	2680	33.15	1.63
Sh Jasrath	1280	2920	30.48	1.57
Sh Roshan lal	1280	2785	31.49	1.57
Sh Mohan Kushwaha	1250	2610	32.38	1.53
Sh Dev Singh Yadav	1267	2712	31.84	1.55
Sh Ramesh Kushwaha	1315	3010	30.40	1.61
Sh Azad	1260	2790	31.11	1.54
Sh Mulayam	1283	2875	30.86	1.57
Average (of all farmers)	**1283**	**2797.75**	**31.44**	**1.57**
Local variety	**1080**	**2586**	**29.46**	**1.32**

Table 125 : Performance of blackgram cv. Uttara

Farmers Name	Yield (kg/ha)		Harvest Index	RWUE (kg/ha/mm)
	Seed	Straw		
Sh Sahjendra Singh Bundela	1365	2621	34.24	1.67
Sh Jasrath	1325	2791	32.19	1.62
Sh Roshan lal	1360	2820	32.54	1.67
Sh Ravi Ahirwar	1315	3810	25.66	1.61
Sh Kashiram	1310	2555	33.89	1.61
Sh Kallu Prajapati	1320	3040	30.28	1.62
Sh Kaluram	1395	2812	33.16	1.71
Sh Ramswaroop	1325	1830	42.00	1.62
Sh Mithailal	1310	2360	35.69	1.61
Sh Kailash Kushwaha	1330	2710	32.92	1.63
Sh Ashok Yadav	1375	3012	31.34	1.69
Sh Bhagvandas Kushwaha	1335	2310	36.63	1.64
Sh Sirnam	1295	2620	33.08	1.59
Sh Bhagirath	1315	2450	34.93	1.61
Sh Kaluram	1385	2450	36.11	1.70
Sh Rajjulal	1390	2864	32.68	1.70
Sh Naval	1370	3098	30.66	1.68
Sh Hajrat yadav	1320	2690	32.92	1.62
Sh Bhushan Kushwaha	1330	2655	33.38	1.63
Sh Dharm Lal	1305	2060	38.78	1.60
Sh Hariram	1285	2960	30.27	1.58
Sh Pran Singh	1340	2820	32.21	1.64
Sh Sivaraj Singh	1295	2785	31.74	1.59
Sh Gyan Singh	1330	2290	36.74	1.63
Sh Jagdish Pal	1360	2455	35.65	1.67
Sh Ram Kumar Purohit	1345	2985	31.06	1.65
Average (of all farmers)	1336	2686.654	33.49	
Local variety	1080	2712.92	28.58	

Fig. 96c : Groundnut cv. Utkarsh

Fig. 96d : Blackgram cv. Azad

Fig. 96e : Blackgram cv. Uttara

Fig. 96 (c to e) : Performance of improved varities

Table 126 : Performance of sesame cv. Shekhar

Farmer's Name	Yield (kg/ha)		Harvest Index	RWUE (kg/ha/mm)
	Seed	Straw		
Sh Sahjendra Singh Bundela	598	2855	17.32	0.73
Sh Pran Singh	616	2960	17.23	0.76
Sh Sivaraj Singh	645	3020	17.60	0.79
Sh Gyan Singh	625	2964	17.41	0.77
Sh Sirnam	622	2845	17.94	0.76
Sh Rakesh	635	3185	16.62	0.78
Sh Ravindra Singh Bundela	605	2936	17.09	0.74
Sh Jasrath	685	2947	18.86	0.84
Sh Ram Prashad	632	2875	18.02	0.77
Sh Kailash Babele	626	2960	17.46	0.77
Sh Chandan Singh	621	2895	17.66	0.76
Sh Pritam Singh Yadav	613	3045	16.76	0.75
Sh Rajpal	610	2960	17.09	0.75
Sh Ashok Yadav	617	2875	17.67	0.76
Average (of all farmers)	**625**	**2951.57**	**17.48**	0.77
Local variety	410	2698.14	13.22	0.50

Table 127 : Performance of Sesame cv. T-78

Farmers Name	Yield (kg/ha)		Harvest Index	RWUE (kg/ha/mm)
	Seed	Straw		
Sh Mithailal	698	2875	19.54	0.86
Sh Ashok Yadav	725	2857	20.24	0.89
Sh Dev Singh Yadav	729	2963	19.75	0.89
Sh Bhagvandas Kushwaha	710	2754	20.50	0.87
Sh Sirnam	717	2865	20.02	0.88
Sh Bhushan Kushwaha	714	3120	18.62	0.88
Sh Azad	712	2890	19.77	0.87
Sh. Akhilesh Pathak	711	2641	21.21	0.87
Sh Santosh	715	2785	20.43	0.88
Sh Sujan kushwaha	726	2689	21.26	0.89
Sh Asharam Kushwaha	705	2987	19.10	0.86
Sh Sripat	709	2968	19.28	0.87
Average (of all farmers)	**714**	**2866**	**19.98**	**0.88**
Local variety	410	2696	13.23	**0.50**

Fig. 96f : Sesame cv. Shekhar

Fig. 96g : Sesame cv. T-78

Table 128 : Performance of Sesame cv. JTS-8

Farmers Name	Yield (kg/ha)		Harvest Index	RWUE (kg/ha-mm)
	Grain	Straw		
Sh Jasrath	3010	687	18.58	0.84
Sh Roshan lal	2610	688	20.86	0.84
Sh Dharm Lal	4020	685	14.56	0.84
Sh Gokul kushwaha	3210	645	16.73	0.79
Sh Hariram	3030	678	18.28	0.83
Sh Mulayam	2540	655	20.50	0.80
Sh Roop Singh	3040	685	18.39	0.84
Sh Dasrath	2530	645	20.31	0.79
Sh Narayan Das	3025	655	17.80	0.80
Sh Bhagvandas	3045	645	17.48	0.79
Sh Puran	3920	695	15.06	0.85
Sh Ganpat	3420	685	16.69	0.84
Sh Jagdish Pal	3820	690	15.30	0.85
Sh Kanhaiya Lal	2840	675	19.20	0.83
Sh Amrat Lal Kushwaha	3140	645	17.04	0.79
Sh Raju	2810	655	18.90	0.80
Sh Annu	1910	685	26.40	0.84
Sh Rajpal Singh Bundela	2020	645	24.20	0.79
Sh Rajendra Singh Bundela	3040	630	17.17	0.77
Sh Kunwar Lal	2012	640	24.13	0.78
Sh Magan Lal	1960	655	25.05	0.80
Sh Hariram	2245	660	22.72	0.81
Sh Atal Ahirvar	2601	675	20.60	0.83
Sh Ram Kumar Purohit	1950	520	21.05	0.64
Sh Virendra Pal	1720	595	25.70	0.73
Sh Narendra Singh Bundela	2034	625	23.51	0.77
Sh Chandan Singh	2410	665	21.63	0.82
Sh Kailash Yadav	2040	685	25.14	0.84
Sh Lal Singh	3512	680	16.22	0.83
Sh Suraj Singh	2430	675	21.74	0.83
Sh Dhoop Singh	2133	695	24.58	0.85
Smt Bitti	2344	685	22.61	0.84
Sh Sobaran	2955	698	19.11	0.86
Sh Lakhan	2645	680	20.45	0.83
Average (of all farmers)	**2705.029**	**662**	**20.23**	
Local variety	2518.765	410	14.17	0.50

Fig. 96h : Sesame cv. JTS-8

Performance of cropping system:

Two sets of cropping systems were hypothecated; i.e., for early onset and late onset of monsoon. The year 2011-12 may be characterized as early onset year. For the situation, the five cropping systems namely; blackgram + sesamum - fallow, sorghum (fodder) – chickpea, sorghum + guar (fodder)-toria, pigeonpea + blackgram-toria, groundnut – wheat were evaluated. During *kharif* pigeonpea + black gram + toria proved better and yielded 1172 kg of blackgram recording a return of Rs.6147/ha whereas, during *rabi* season wheat is more suitable in terms of total return groundnut- wheat rotation proved best and recorded gross return of Rs. 11868/ha.

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements diesel pumpset, seed drill, leveler, disc plough, rotavator, cultivator, sprayer, power sprayer and decorticator gave higher output energy and crop yield compared to normal implements. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period.

Alternate land use

Agri-horti pasture system was established in four farmers fields. The establishment was successful at three sties only. (Table 129 & 130) (Fig. 96i).

Table 129 :Performance of Agri-horti -pasture systems

Farmer's Name	Plants planted (No.)			Grasses (no. of rooted slips, kg)			
	Guava	*Aonla*	*Citrus*	*Cenchrus (No.)*	*Guinea (No.)*	*Stylosanthes hamata (kg)*	*S. seabrana (kg)*
Sh Mohan Kushwaha	20	15	20	750	250		1
Sh Vinod Kushwaha	20	16	10	750	250	1	
Md Siddique	70	31	39		150	2	

Table 130 : Performance of the Agri-horti -pasture systems

Farmer's Name	Establishment			Pasture production/ (kg/sq m)			
	Guava	*Aonla*	*Citrus*	*Cenchrus*	*Guinea*	*Stylosanthes hamata*	*S. seabrana*
Sh Mohan Kushwaha	12 (60)	4 (26.6)	10 (50)	2.32	6.21		4.22
Sh Vinod Kushwaha	13 (65)	0 (0)	7 (70)	1.38	4.68	3.65	
Md Siddique	70 (100)	21 (67.7)	39 (100)		7.88	2.98	

* Figures in parentheses shows the percent establishment

- The germination of papaya Cv.Pusa Nanha was very poor.
- The rejuvenation of old Desi ber through budding with improved cultivars viz., Gola, Banarasi Karaka and Umran was carried out

Fig. 96i : Horti Silvi pasture system

1.6. Soybean Based Production System

1.6.1 INDORE

a. Agro-ecological setting

The Indore center is located in Central highlands (Malwa) Gujarat plain Kathiawar peninsula semi-arid eco-region (AESR 5.1) and Malwa plateau in Madhya Pradesh. The climate is hot dry semi-arid, annual rainfall is 944 mm. Annual potential evapo-transpiration is 616 mm.

b. On-station experiments

At Indore, the onset of monsoon was during second fort night of June i.e. five to six days delay. A rainfall of 1585 mm was received during cropping period of 2011 as against normal of 919 mm. An excess rainfall of 113, 212 and 410 per cent was received during August, September and October months when compared to normal rainfall. However, a deficit rainfall of 93, 59.5, 11.5 and 100 per cent was received during June, July, November and December months (Fig. 97), respectively as compared to normal rainfall. There were totally 55 rainy days during cropping period .

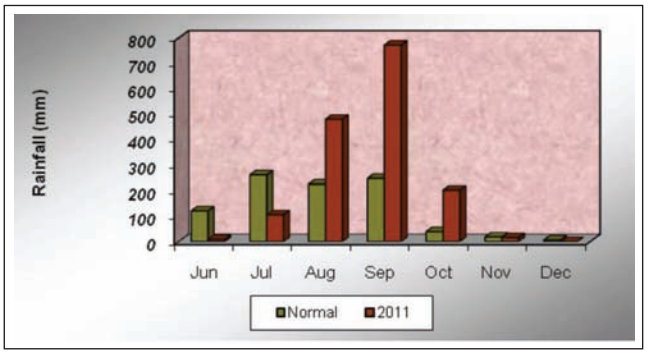

Fig. 97 : Normal and actual (2011) monthly rainfall at Indore

Rainwater management

The rainwater was harvested in farm pond and efficiently utilized for supplemental/presowing irrigation for the component crops in farming system model.

The net returns of Rs. 6650/ha (BC ratio, 1.27) was recorded by sweet corn (green cobs), followed by tomato Rs. 55370/ha with BC ratio of 2.23 planted after sweet corn. The net return of Rs. 17807/ha was recorded by chickpea with BC ratio of 2.62 grown after soybean.

The vegetables *viz.,* bottlegourd (30 plants), sponge gourd (12 plants), bitter gourd (40 plants) and sem (*Dolicus lablab*) (10 plants) were planted on the bunds of farm tank whose perimeter is of 160 m and the income thus, generated was of Rs. 5661/ ha (Table 131).

Real time contingency crop planning

Among different intercropping systems evaluated, maximum and significantly higher greengram equivalent yield of 1208 kg/ha, RWUE of 0.66 kg/ha/mm with a net returns of Rs. 28611/ha and BC ratio of 2.75 were attained by sunflower with 20% higher seed rate, followed by sunflower with normal seed rate gave a greengram equivalent yield of 1107 kg/ha, RWUE of 0.53 kg/ha/mm with a net income of Rs. 21707/ha and BC ratio of 2.17. The sesame with 20% higher seed rate system gave the lowest greengram equivalent yield of 272 kg/ha, RWUE of 0.34 kg/ha/mm with net income of Rs.11898/ha and BC ratio of 1.40 in the season (Table 134).

Table 131 : Seed, tuber, green cob and fruit yield (kg/ha) and economic returns and BC ratio of different component of farming system model – Indore, 2011-12

Cropping Sequence	Crops	Yield (kg/ha)	Cost of Cultivation (Rs/ha)	Net Return (Rs/ha)	BC ratio
Sweet maize (*Kh.*) –tomato	Sweet corn (*Kh.*)	3165	25000	6650	1.27
	Tomato	10037	45000	55370	2.23
Soybean – potato-	Soybean	1401	13000	22017	2.69
	Potato	3923	45000	(-) 25383	(-) 0.44
Soybean- chickpea	Soybean	1454	13000	23358	2.80
	Chickpea	823	11000	17807	2.62
Additional Income (‘)	Vegetables planted on tank bund in running meter area.	-	5661	-	

Table 132 : Performance of intercropping systems for contingent crop planning

Treatment	Seed yield (kg/ha)		Greengram eq.yield (kg/ha)	Net returns (Rs/ha)	RWUE (kg/ha/ mm)	BC ratio
Green gram with normal seed rate	605	-	605	22265	0.51	2.78
Green gram with 20% higher seed rate	713	-	713	27424	0.60	3.33
Sunflower with normal seed rate	793	-	634	21707	0.53	2.17
Sunflower with 20% higher seed rate	975	-	780	28611	0.66	2.75
Sesame with normal seed rate	277	-	332	8617	0.28	1.08
Sesame with 20% higher seed rate	340	-	408	11898	0.34	1.40
Green gram + sesame (4 :2) normal seed rate	332	103	456	14794	0.38	1.85
Green gram + sesame (4 :2) 20% higher seed rate	385	119	528	17671	0.44	2.02
Green gram + sunflower (4 :2) normal seed rate	472	287	702	27082	0.59	3.39
Green gram + sunflower (4 :2) 20% higher seed rate	519	317	773	30001	0.65	3.48

Contingent crops planning

Under contingent crop planning with aberrant monsoon to combat the abiotic stress the effect of spraying of VAM-C 50 % SL @ 3.75 l/ha; potassium Solution @ 2%; thiourea @ 250 g/ha at the reproductive stage of the crop were studied on four crops *viz.,* soybean, maize, blackgram and horsegram. The spraying of VAM-C 50% SL @ 3.75 l/ha recorded the significantly high seed yield/ha followed by the spraying of potassium solution @ 2% as compared to the control *i.e.,* without spray and spray of VAM-C 50% SL @ 3.75 l/ha on soybean, maize, blackgram and horsegram recorded 17.5, 27.0, 35.9 and 42.3% higher seed yield respectively, than control (no spray of chemical) (Table 133).

Effect of organic manures and fertilizers on sweetcorn

Application of FYM 12 t/ha gave the higher green cob yield of 8827 kg/ha, with net income of Rs. 62338/ha and BC ratio of 3.40 followed by Vermicompost 5 t/ha+ 50% RDF (60: 30: 30 NPK kg/ha), (green cob yield of 8519 kg/ha, with net income of Rs. 50288/ha and BC ratio of 2.44) and RDF (60: 30: 30 NPK kg/ha) recorded green cob yield of 8333 kg/ha, with net income of Rs. 58353/ha and BC ratio of 2.44), respectively. The lower green cob yield of 5617 kg/ha, with net income of Rs. 36236/ha and BC ratio of 2.82 was exhibited by control. The variety, NK 6240 recorded maximum green cob yield of 12284 kg/ha with net returns of Rs. 95059/ha and BC ratio of 4.52.

Table 133 : Performance of rainfed *kharif* crops with foliar spray under aberrant monsoon condition

Treatments	Seed yield (kg/ha)	Soybean equivalent yield (SEY) (kg/ha)	Net returns (Rs/ha)	BC ratio
Main treatment				
Soybean (JS 93-05)	1925	1925	35115	3.70
Maize (HKI-163)	1603	705	4635	1.36
Blackgram (JU- 86)	319	767	6167	1.47
Horsegram (HG 563)	565	1017	12417	1.96
S Em	66	50	-	-
CD (5%)	193	146	-	-
Sub treatment				
Control	911	896	9391	1.72
Spray of VAM-C 50 % SL @ 3.75 l/ha	1227	1251	18267	2.41
Spray of potasium Solution @ 2%	1079	1055	13374	2.03
Spray of thiourea @ 250 g/ha	1195	1212	17302	2.33
S Em	39	45	-	-
CD (5%)	**113**	**131**	-	-

Chickpea cv. JG 412 recorded the higher yield of 936 kg/ha, followed by IG 379 (706 kg/ha) and IG 370 (468 kg/ha). The yield differences of cultivars were significant (Table 134).

Weed management

Weed management in soybean the treatments weed free up to 60 DAS recorded highest (1469 kg/ha, net returns of Rs. 22228 ha^{-1} and BC ratio 2.53) followed by T6-Pendimethalin 30 EC @ 1000g $a.i.ha^{-1}$ (PE) + imazethapyr 10% SL @ 100g $a.i.ha^{-1}$ (20 DAS) (E-PoE) (1404 kg/ha, net returns of '19458ha^{-1} and BC ratio 2.24),T2-Imazethapyr 10%SL @ 100g $a.i.ha^{-1}$ (20 DAS) (E-PoE) (1287 kg/ha, net income of Rs. 17726 $ha^{-1}$and BC ratio 2.23 and were at par and significantly superior than other treatments. All these three treatments were economically viable as exhibited by high BC ratio and control weeds effectively as depicted by low weed index. The lowest yield of 926 kg/ha was recorded by the control *i.e.,* weedy check (Table 135).

Evaluation of soybean varieties for rainfed conditions

Among 3 varieties *viz.,* JS 335, JS 95-60 and JS 93-05 of soybean evaluated at station and on farmers' field at Indore, JS-335 was superior with a maximum and significantly higher yield of 2029 kg/ha, 1.39 kg/ha/mm of RWUE, net returns of Rs. 37725/ha and BC ratio of 3.90, followed by the variety JS 95-60, recorded second highest yield of 1869 kg/ha, 1.28 kg/ha/mm of RWUE, net returns of Rs. 33725/ha and BC ratio at station trial. During 2011, 1454.8 mm rainfall was received in 45 days during crop season. No dry spell was observed during the crop season (Table 136).

Table 134 : Performance of varities of sweet maize in *kharif* and chickpea in *rabi*

Treatments	Sweet maize in *kharif*				Chickpea in *rabi*		
	Greencob yield (kg/ha)	Net returns (Rs/ha)	BC ratio		Seed yield (kg/ha)	Net returns (Rs/ha)	BC ratio
Main treatment							
Sugar75	4691	19131	1.68	JG-412	936	21753	2.98
Sugar queen	6389	36106	2.35	ID 370	468	5366	1.49
NK 6240	12284	95057	4.52	IG 379	706	13716	2.25
Sub treatment							
Control	5617	36239	2.82	T1	433	4167	1.38
RDF (120:60:60)	8333	58353	3.34	T2	784	16438	2.49
Vermicompost 5t ha^{-1}	7531	42875	2.32	T3	743	15012	2.36
Vermicompost 5t ha^{-1}+ 50% RDF	8519	50228	2.44	T4	788	16589	2.51
FYM 12t ha^{-1}	8827	62338	3.40	T5	755	15423	2.40
FYM 12t ha^{-1} + 50% RDF	7901	50555	2.78	T6	715	14040	2.28

Table 135 : Evaluation of various herbicides to control weeds in soybean

Treatment	Seed yield (kg/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio	RWUE (kg/ha/mm)	Weed index (%)
Imazethapyr 10% SL @ 100g $a.i.ha^{-1}$ (20 DAS) (E-PoE)	1287	32176	17726	2.23	0.89	12.4
Pendimethalin 30EC @ 1000g $a.i.ha^{-1}$(Pre-em) + imazethapyr 10% SL @ 100g $a.i.ha^{-1}$at (20 DAS) (E-PoE).	1404	35108	19458	2.24	0.97	4.4
Interculture at 15 DAS & imazethapyr 10% SL @ 100g $a.i.ha^{-1}$at (20 DAS) (E-PoE).	1096	27392	12592	1.85	0.76	25.4
Weed free upto 60 DAS	1469	36728	22228	2.53	1.02	00.0
Weedy check (Control)	926	23148	10148	1.78	0.64	37.0
S.E (±)	**78**	-	-	-	-	-
CD (5%)	**228**	-	-	-	-	-

Evaluation of Pigeonpea lines for rainfed conditions

Twenty six progenies and seven advanced breeding lines were tested with the checks *viz.,* JKM – 189, JA 4 (medium maturing varieties *i.e.,* 170-175 days) and ICPL 88039 and UPAS 120 (early maturing varieties *i.e.,* 130-140 days). The promising progenies identified were as below (Table 137).

Table 136 : Evaluation of soybean varieties under rainfed condition

Variety	Seed yield (kg/ha)	RUE (kg/ha/mm)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
JS 335	2029	1.39	50725	37725	3.90
JS 95-60	1869	1.28	46725	33725	3.59
JS 93-05	1650	1.13	41250	28250	3.17
Local	1350	0.93	33750	20750	2.60

Note: Cost of cultivation: Rs 13000ha^{-1}. Market rate: Seed- Rs.25kg^{-1}

Table 137 : Evaluation of promising strains and advanced breeding lines of pigeonpea under rainfed condition

Character	Category	Frequency	Name of entry
Seed yield (kg ha^{-1})	Ranged from 208.3 kg ha^{-1} (ICP 8863 08-39) to 2014.6 kg ha^{-1} (JA 4 08-14)		
	Above 2000 kg ha^{-1}	01	JA 4 08-14 (2014.6 kg ha^{-1})
	1500 – 1999 kg ha^{-1}	03	ICP 8863 08-38 (1770.8 kg ha^{-1}) ICP 8863 08- 40 (1775.2 kg ha^{-1}) JKM 189 (1510.4 kg ha^{-1})
	1000 – 1499 kg ha^{-1}	13	Ranged from 1020.8 kg ha^{-1}(ICP 8863 08- 42) to 1330.2 kg ha^{-1}(JA 4)
Seed index (g per 100 seed)	Ranged from 8.30 g (ICPL 88039 08-02 and JA 4 08-10) to 12.20 g (ICP 8863 08-40)		
	Above 12.00 g	01	ICP 8863 08-40 (12.20 g)
	10.00 – 11.99 g	05	JIA 65 (10.00 g) ICP 8863 08-39 (10.00 g) JA 4 08-14 (10.00 g) Badnawar Selection (10.10 g) Panod Selection (10.50 g)
	9.50 – 9.99 g	11	Ranged from 9.60 g (JA 4 08- 15, JKM 189 08-24, (ICP 8863 08- 23, JKE 114E) to 9.80 g (ICPL 88039 08-07, (ICP 8863 08- 38, ICPH 2671, MN 5, ICPL 88039)
Earliness (days)	Ranged from 150 days (ICPL 88039 08-03, ICPL 88039 08-05 and ICPL 88039 08-06,) to 179 days (ICPH 2671)		
	Less than 149 days	Nil	
	150 – 159 days	17	ICPL 88039 08-03, ICPL 88039 08-05, ICPL 88039 08-06 (150 days); ICP 8863 08-19, ICPL 88039 (154 days); JA 4 08-09, JA 4 08-20 (155 days); JA 4 08-16, ICP 8863 08-40, ICP 8863 08-41 (156 days); ICPL 88039 08-04, JA 4 08-15, JIA – 65 (158 days); JA 4 08-10, JA 4 08-11, Sel. Panod, JA 4 (159 days)

Character	Category	Frequency	Name of entry
	160 – 169 days	11	JKM 189 08-30, JKM 189, MN – 5 (160 days); ICP 8863 08-38 (161 days); ICP 8863 08-23, JKE – 115 E (162 days); JKE – 114 E (164 days); ICPL 88039 08-01 (165 days); ICP 8863 08-39 (167 days); JA 4 08-14 (168 days)
	More than 170 days	09	ICPL 88039 08-07, JKM 189 08-24 (170 days); DT – 501 (171 days); JKM 189 08-37, UPAS 120 (172 days); JKE – 116 E (174 days); Sel. Badnawar (176 days); ICP 8863 08-23 (178days); ICPH 2671 (179 days)

c. On-farm experiments

Village profile

The program was implemented by AICRPDA centre, Indore in Nignoti village in Indore district, Madhya Pradesh. The total cultivated area is 248 ha out of which 100 ha is rainfed. The mean annual rainfall was 954 mm with seasonal rainfall of 1559 mm during *kharif* (June-September 2012). The major soil types are medium deep to deep black soils. The major rainfed crops during *kharif* are soybean, maize, sorghum and during *rabi* are wheat and chickpea. The number of small, marginal, and large farmers is 65, 47 and 137, respectively. The ground water table is 20 m. The sources of irrigation are open well, bore well, tube well, farm ponds, *nallah etc.,* covering 60 per cent of cultivated area.

Climate Variability in General

In general, the climate in this agro-climatic zone is semi-arid. The south-west monsoon contributes 90 - 94 %, north-east monsoon 3 - 6 % and summer 3 - 4 % of the total annual average rainfall of 954 mm. The onset (south-west) of monsoon is during 24 SMW. The dry spells during crop season were experienced in September and at seed formation stage of the soybean and maize. The onset of the monsoon is normal or shifts about 8-10 days *i.e.,* 26 SMW (June end) and the withdrawal is early (37 SMW). The data on normal and actual maximum and minimum temperatures follow the same trend from 19 SMW to 49 SMW. Thereafter, from 50 SMW to 20 SMW the actual values of were lower than the corresponding normal values. Thus, the maximum and minimum temperatures have decreased for *rabi* crops. The extreme events like unusual and high intensity rainfall in short span had been increasing as the rains were recorded between 22 SMW to 42 SMW with two peaks of more than 250 mm per week during 34 and 35 SMW. Further, there had been three peaks of more than 100 mm per week and these are 28, 30 and 32 SMW during *kharif* and no rains were received during *rabi* seasons. The region had been experiencing other extreme events like frost. There were four events of occurrence of frost that was on 14th, 15th, 22nd January and 9th February 2012. There had been considerable shift in rainfall pattern and sowing window for soybean was from 23 SMW to 25 SMW. For the last eight decades (1930 to 2010) the maximum and minimum temperatures showed increasing trend while decreasing trend of rainfall for the same period at Indore.

Experienced weather conditions during the year (2011-12)

The village received 1584.4 mm which was *excess of* 630.4 mm compared to normal 954 mm. The onset of monsoon was *normal*. The crops experienced no dry spells. The intense rainfall events were experienced of 108.4 mm on 23.07.2011; 110.0 mm on 21.08.2011 and 156.2 mm on 24.08.2011 during crop growing season *kharif* (Fig 98). These events impacted the stand/ performance of soybean,

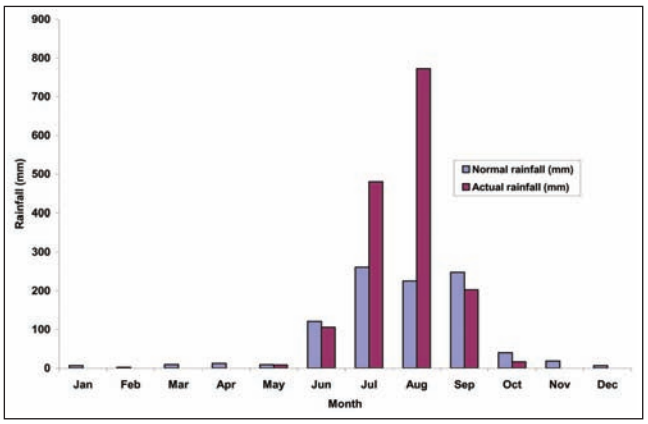

Fig. 98 : Normal and actual (2011) monthly rainfall at Nignoti Village

maize and pigeonpea crops. The temperatures (maximum and minimum) during *rabi* were lower than the corresponding normal values and the area experienced four viz., 14th, 15th, 22nd January and 9th February 2012. Events of occurrence of frost recorded minimum temperature lesser than 2°C which impacted long duration crops like pigeonpea and chickpea.

Interventions

The major on-farm interventions were implemented included crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 32 ha in 129 farmers' fields.

Real Time Contingency Crop Planning

Crops/ Varieties/cropping system

Under this component, the improved varieties of soybean *viz*., JS-335, JS 93-05, JS 95-60 (Fig. 99) during *kharif* and chickpea *viz*., JG-412, JG-16, IG-593 (Fig. 100) and wheat *viz*., GW 366, Purna, Poshan (Fig. 101) during *rabi* were introduced to cope with the rainfall variability of the region.

There was 39.8 % and 36.0% increase in the productivity of chickpea and wheat, respectively with higher productivity by chickpea variety, JG-412 (42.9%) and wheat variety, Poshan (44.2%). In case of soybean, the performance of farmers' local variety and improved varieties was at par and the farmers' local variety was one of the improved varieties of recent past (Table 138).

Soybean + maize intercropping

In soybean + maize (4:2) intercropping system, both the crops were sown at the onset of monsoon. This intercropping system performed well initially. Soybean gave seed yield of 1512 kg/ha with RWUE of 1.02 kg/ha/mm and BC ratio of 2.91.

Nutrient management in soybean

The improved practice of balanced nutrition (24:64:32 N: P: K per ha) recorded 21.49 per cent increase in seed yield over farmers' practice. The improved practice recorded seed yield of 1837 kg/ha; RWUE of 1.24 kg/ha/mm and 2.98 BC ratio as compared to the farmers' practice *i.e.,* (9:23:0 N: P: K per ha) through 50 kg / ha DAP (18:46 N:P) exhibited seed yield of 1512 kg/ha, RWUE of 1.02 kg/ha/mm and BC ration of 2.68 (Table 139).

Table 138 : Performance of rainfed *kharif* crops (under excess rainfall) and *rabi* crops (under no rainfall) situations

Crop	Variety	Yield (kg/ha)		% increase	BC ratio
		Improved practice	Farmers' practice		
Soybean	JS-335	1600.0	1584.0	-	3.08
	JS 93-05	1520.0	1584.0	-	2.92
	JS 95-60	1581.0	1584.0	-	3.04
	Average	**1567.0**	**1584.0**	**-**	
Chickpea	JG-412	1180.5	826.0	42.9	4.80
	JG-16	1124.5	826.0	36.1	4.60
	IG-593	1158.5	826.0	40.3	4.70
	Average	**1154.5**	**826.0**	**39.8**	
Wheat	GW-366	4440.0	3440.0	29.1	4.14
	Purna	4640.0	3440.0	34.9	4.33
	Poshan	4960.0	3440.0	44.2	4.36
	Average	**4680.0**	**3440.0**	**36.0**	

Table 139 : Balanced nutrition in soybean

	Treatment		% increase in yield
	Improved practice Balanced fertilizers *i.e.* 24:64:32 N: P: K per ha through IFFCO (12:32:16)	**Farmers practice** Farmers practice *i.e.*, 9:23:0 N: P: K per ha through 50 kg / ha DAP (18:46 N: P)	
Seed yield (kg/ha)	1837	1512	21.49
RWUE (kg/ha/mm)	1.24	1.02	
B:C ratio	2.98	2.68	

Fig. 99 : Performance of improved varieties of soybean

Fig. 100 : Performance of improved varieties of chickpea

Fig. 101 : Performance of improved varieties of wheat

Rainwater harvesting (*in situ* and *ex situ*) and its efficient use

A farm pond size of 37m X 16m X 6m capacity 2076 m^3 was dug (Fig. 102) for efficient rainwater harvesting and recycling. The stored water in the farm pond during this year was efficiently utilized for pre-sowing irrigation of *rabi* crops *i.e.,* wheat or chickpea (Fig. 103a) which resulted in higher yield, net returns and BC ratio both in chickpea and wheat compared to no persowing irrigation (Fig. 103b) (Table 140).

Fig. 102 : Efficient rainwater harvesting in farm pond in Nignoti village

The polythene mulching in inter row spaces of soybean increased the seed yield by 41 per cent compared to no mulching (1223 kg/ha) (Fig. 104a, 104b) (Table 141).

Timely operations through Custom Hiring Centre

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements seed drill, reversible plough, a set of hand sprayer and power sprayer were made available in the custom hiring centre. Sowing of soybean with improved seed drill (Fig. 105) gave higher energy output (Table 142).

Alternate land use system for carbon sequestration and ecosystem services

Mango and guava based agri-horti system with soybean – chickpea crops were demonstrated in farmers' fields. These interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies.

Fig. 103a : Performance of wheat and chickpea with one pre-sowing irrigation

Fig. 103b : Farmers' practice - dry sowing of wheat and chickpea

Table 140 : Performance of chickpea and wheat with presowing irrigation from the harvested rainwater

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net returns (Rs/ha)	BC ratio
		Pre-sowing irrigation	Without irrigation			
Chickpea	JG-412	1600	988	61.94	61000 33460	6.55 4.04
Wheat	GW-366	5200	3600	44.44	57800 35400	4.85 3.36

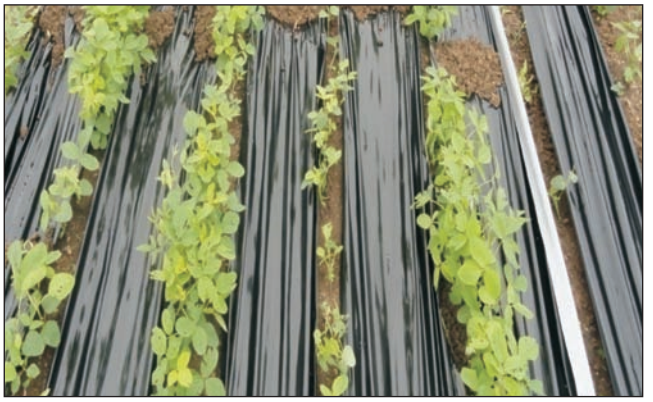

Fig. 104a : Improved practice - Use of polythene mulch in soybean

Fig. 104b : Farmers' practice - Without mulch in soybean

Table 141 : Table. *In-situ* moisture conservation with polythene mulching

	Treatments		% increase
	Improved practice Polythene mulch in inter row spaces of crop	Farmers' practice Without mulch	
Seed yield (kg/ha)	1727	1223	41.21
RWUE (kg/ha/mm)	1.16	0.83	
BC ratio	1.90	1.82	

Fig. 105 Sowing of soybean with improved seed drill

Table 142 : Performance of improved seed drill in soybean

	Energy (MJ) for improved implement		Energy (MJ) for normal implement		% change due to improved implement	
	Input	Output	Input	Output	Input	Output
Seed drill	2646	23360	3528	21900	(-) 25.0	6.66
Yield (kg/ha)	1600	1500	6.66			
Net return (Rs/ha)	27000	24500	10.20			
BC ratio	3.08	2.88	6.94			

1.6.2. REWA

a. Agroecological setting

Rewa centre is located in keymore plateau and Satpura hill zone in Mahdya Pradesh.

b. On-farm experiments

Village profile

The program is being implemented in the village Raura and Patauana Block and Tehsil Raipur Karchulian in district Rewa (M.P.). The total cultivated area is 743.986 ha (477.785 ha + 166.201 ha) out of which 250.997 ha (129.210 ha + 121.787 ha) is rainfed. The mean annual rainfall is 1080mm with seasonal rainfall of 943.2mm during kharif (June-September). The major soil types are silty laom and silty clay laom . The major crops in *kharif* under rainfed are rice, soybean, pigeonpea, blackgram and *rabi* are wheat, chickpea, lentil, linseed. The number of small, marginal, medium and large farmers are 347 (310 + 37), 192(110+82) and 137 (127 +10) in Raura and Patauna Villages respectively. The ground water table is 30 M. The source of irrigation is bore wells covering 60% of cultivated area.

Climate Variability in General

In general, the climate in this agro-climatic zone is sub-humid. The south-west monsoon contributes 85 % and north-east monsoon 15% of the total annual average rainfall of 1080mm. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon was 15-35% deficit of the average rainfall. The onset (south-west) of monsoon was during 25 SMW (standard meteorological week) and north-east monsoon is 47 SMW. The dry spells during crop season were experienced for the past 10/15 years during August and September at flowering and grain formation stages of the major rainfed crops. The onset of the monsoon is normal. The soil moisture status is deficit during flowering and grain development stages of major rainfed crops.

Experienced weather conditions during the year (2011-12)

The village received 992.0 mm rainfall which was excess i.e. 48.8 mm compared to normal (943.2 mm) during south-west monsoon. The onset of monsoon was normal. The crops did not experience any dry spells during the season.

Fig. 106a : Performance of *kharif* crops with ridge furrow system

Fig. 106b : Farmers practice - flooded crop fields due to no proper land configuration

Interventions

The package included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 59.2 ha in 148 farmer's fields.

Land configuration

The land configuration included ridge furrow system enhanced *in-situ* moisture conservation resulting in increased crop yield of soybean, rice, blackgram, sesamum, wheat, chickpea and lentil (Fig. 106a) and rainwater use efficiency by 20-30 % compared to farmers practice (Fig. 106b) (Table 143).

Crops/ Varieties/cropping system

Under this component, the suitable varieties of rainfed crops like soybean (JS 93-05, JS 95-60, JS 335) during kharif and wheat (GW 273), chickpea (JG 315), lentil (JL 3) during abi were introduced to cope with the rainfall variability of the region. However, during the cropping season, the onset of monsoon was normal and crops did not experience any dry spell.

Rainwater harvesting and recycling

A farm pond size of 20x15x6 m capacity 1800 m^3 was used for efficient rainwater harvesting and recycling. The stored water in the farm pond during this year was efficiently utilized for supplementary irrigation of 5 cm as pre-sowing irrigation for chickpea (Table 144).

Table 143 : Performance of improved varities of *kharif* and *rabi* crops

Crop	Variety	Yield (kg/ha)		RWUE (kg/ha/mm)	BC ratio
		Improved practice	Farmers practice		
Soybean	JS 93-05	2300	2100	2.0	4.6
	JS 335	2200	1900	1.9	4.4
Blackgram	PU 30	950	700	0.8	4.7
	PDU-1	950	750	0.8	4.7
	LBG-20	950	650	0.8	4.7
Pigeonpea	Asha	2000	1900	1.7	8.0
	TJT-501	1800	1700	1.5	7.2
	ICPL 88039	2200	2000	1.9	8.2
Rice	Sehbhagi	2600	2300	2.2	2.1
	Danteshwari	2700	2100	2.3	2.2
	JR-201	2600	1800	2.2	2.1
Wheat	GW-273	3000	2500	59.7	4.2
Chickpea	JG-322	1800	1600	35.8	5.5
Lentil	JL-3	1500	1100	29.8	6.0

Table 144 : Performance of chickpea (JG-322) with supplemental irrigation

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net returns (Rs./ha)	BC ratio
		Supplementary irrigation	Without irrigation			
Chickpea	JG-322	1900	1700	11.8	57300	5.4

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements MB plough, Cultivator, Disk harrow, Seed cum fertilizer drill, ridge seeder, raised bed seeder, hand wheel hoe, sprayer cum duster, hand operated sprayer and duster. Use of rotavater, MB plough, seed drill and weeder in *kharif* and *rabi* crops gave higher net returns (Table 145).

Table 145 : Performance of *kharif* and *rabi* crops with improved implements

Implement	Crop	Variety	Net returns (Rs./ha)	BC ratio
Rotavator	Wheat	GW-273	25000	3.5
	Chickpea	JG-322	47200	4.9
	Lentil	JL-3	30400	4.8
	Blackgram	LBG-20	77000	6.1
	Soybean	JS 335	104700	7.9
MB-plough	Wheat	GW-273	29200	3.9
	Chickpea	JG-322	54600	5.5
	Lentil	JL-3	33600	5.2
	Blackgram	LBG-20	87000	6.8
	Soybean	JS 335	104700	7.9
Seed drill	Wheat	GW-273	27800	3.7
	Chickpea	JG-322	50900	5.2
	Lentil	JL-3	40000	6.0
	Blackgram	LBG-20	78600	6.2
	Soybean	JS 335	98600	7.5
Weeder	Wheat	GW-273	26400	3.6
	Chickpea	JG-322	54600	5.5
	Lentil	JL-3	36800	5.6
	Blackgram	LBG-20	85000	6.6
	Soybean	JS 335	98800	7.5
Harvester	Wheat	GW-273	29200	3.9
	Chickpea	JG-322	47200	4.9
	Lentil	JL-3	27200	4.4
	Blackgram	LBG-20	81900	6.4
	Soybean	JS 335	92700	7.1

1.7. Groundnut Based Production System

1.7.1 ANANTAPUR

a. Agro-ecological setting

Anantapur is in Rayalaseema- Karnataka plateau (*AESR 3*). The climate is hot arid. Annual potential evapo-transpiration is 641 mm. Annual average rainfall is 615 mm. Length of growing period is 90-120 days.

b. On-station experiments

At Anantapur, the onset of monsoon was normal i.e. first week of June. A rainfall of 363.8 mm was received during cropping period as against the normal of 513.9 mm in 2011. An excess rainfall of 20.2% was received during October over the normal rainfall. However, a deficit rainfall of 14.6, 2.6, 41.1, 73.4, 26.1 and 83.3 per cent was received during June, July, August, September, November and December months, respectively as compared to normal rainfall of these months (Fig. 107).

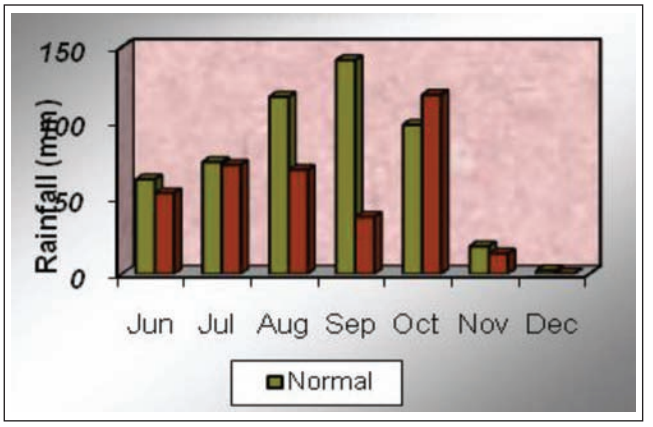

Fig. 107 : Normal and actual (2011) monthly rainfall at Anantapur

Real time contingency crop planning

Groundnut variety Kadiri Haritandhra recorded higher pod (801 kg/ha) and haulm yield (2426 kg/ha) followed by Narayani and ICGV-91114 under normal onset of monsoon. Further, Kadiri Haritandhra recorded higher net returns (Rs 26530/ha) and BC ratio (1.5) under normal onset of monsoon (Table 146).

pigeonpea variety PRG-158 recorded higher net returns and BC ratio of pigeonpea followed by PRG-100 and LRG-30 (Table 147).

Sowing during second fortnight of July as well as during sedond fortnight of August recorded higher pod yield with contingency measure of leaf webber control and post emergence weed control with Quizalofop–ethyl @1.5 lt/ha due to well distributed rainfall during pod development stage (Table 148).

Sowing of horsegram variety (CRHG-21) after harvesting of groundnut during *kharif,* 2011-12 recorded seed yield of 730kg/ha (Table 149).

Table 146 : Performance of improved varieties of groundnut under normal onset of monsoon

Treatments	Pod yield (kg/ha)	Haulm yield (kg/ha)	RWUE (kg/ha-mm)	Gross returns (Rs./ha)	Net returns (Rs./ha)	BC ratio
K-6	608	2055	3.4	38740	20740	1.2
K-9	666	3407	3.7	40480	22480	1.2
Kadiri Harithandhra	801	2426	4.5	44530	26530	1.5
Vemana	689	1556	3.9	41170	23170	1.3
Narayani	797	1740	4.5	44410	26410	1.5
ICGV-91114	773	1499	4.3	43690	25690	1.4
ICGV-86015	689	1926	3.9	41170	23170	1.3
ICGV-00308	710	1542	4.0	41800	23800	1.3
TMV-2	537	2021	3.0	36610	18610	1.0

Table 147 : Performance of improved varieties of pigeonpea under normal onset of monsoon

Treatments	Plant height (cm)	No. of branches/plant	No. of pods/plant	Pod length (cm)	Seed yield (kg/ha)	RWUE (kg/ha/mm)	BC Ratio
LRG30	168.3	3	102.8	4.2	361	1.1	2.0
LRG41	192.1	3.4	133.6	4.1	301	1.0	1.8
PRG100	153	3.6	62.2	3.7	390	1.2	2.1
PRG158	152.6	3.6	102.6	4	532	1.7	2.5
TRG 22	147.8	2.6	43.6	4.2	206	0.7	1.6
WRG27	139.7	3.4	70.6	4.1	258	0.8	1.7
WRG53	129.3	2.8	76.6	3.6	308	1.0	1.9
BRG1	161.7	3.8	93	5	252	0.8	1.7
TTB 7	176	3.4	134.8	4.28	26	0.1	1.1
BRG2	188.4	3.6	95.2	5.7	85	0.3	1.2
ICPL85063	204.4	3	108.6	4.1	112	0.4	1.3

Table 148 : Contingency practices in groundnut

Date of sowing	Contingency measures	Yield (kg/ha)		Date of harvest	RWUE (kg/ha/mm)
		Pod	Haulm		
3-6-2011	Dead furrows at 3.6 m interval + Threshing with fresh pod tripper and Horsegram sowing after harvest of groundnut (October)	778	2315	28-9-2011	3.7
7-7-2011	Leaf webber control by mass trapping, dead furrows at 3.6 m interval ,*wild bajra* control	423	1813	29-10-2011	2.3
22-7-2011	Leaf webber control by mass trapping, dead furrows at 3.6 m interval ,*wild bajra* control	965	1335	24-11-2011	3.8
16-8-2011	Leaf webber control by mass trapping, *wild bajra* control	977	1543	8-12-2011	4.3
23-8-2011	Leaf webber control by mass trapping	889	1703	1-12-2011	6.7
2-9-2011	Leaf webber control by mass trapping	648	1806	14-12-2011	3.8

Table 149 : Growth parameters and yield attributes of horsegram sown after harvest of groundnut during *kharif*, 2011-12

Plant character	Horsegram (variety CRHG-21)
Plant height (cm.)	31
No. of branches/plant	4
No. of pods/plant	21.6
No. of seeds / pod	5.8
Seed yield (kg/ha)	730
Bhusa yield (kg/ha)	578
100- seed weight (g)	3.51

Studies on roof rainwater harvesting for crop production

About 800 m^2 roof areas with a storage capacity of 16000 was established for the office main building. During the season an amount of 270 mm was received and 159 mm (59%) was utilized for vegetable cultivation. With this collected rainwater tomato and brinjal crops were raised and recorded yields of 2882 kg/ha and 1429 kg/ha respectively (Table 150).

During *kharif* 2011, wet spell during flowering period had more impact on pod yield of groundnut than wet spell during pegging stage. Wet spell coincided with low sunshine hours which had drastic effect on pod yield of groundnut. K-6 and Narayani recorded higher pod yield during wet spells than TMV-2. Groundnut sown during August recorded higher pod yield due to higher rainfall received during pod development stage (Table 151).

Table 150 : Roof rainwater harvesting during *kharif* 2011

Date	Rainfall (mm)	Rain water collected (lt)	Excess water (lt)
14-7-2011	3.6	2880	
21-7-2011	7.0	5600	
26-7-2011	17.0	13,600	
27-7-2011	22	17,600	15200
31-7-2011	2.6	2080	
3-8-2011	3.0	2400	
16-8-2011	5.0	4000	
17-8-2011	5.4	4320	
20-8-2011	3.2	2560	
21-8-2011	23.0	18400	4960
22-8-2011	27.0	21600	21600
2-9-2011	7.6	6080	
14-9-2011	27.0	21600	5600
4-10-2011	5.6	4480	
11-10-2011	62	49600	33600
14-10-2011	5.8	4640	
27-10-2011	8.2	6560	
28-10-2011	22.4	17920	8480
30-10-2011	12.4	9920	
Total	**269.8**	**215840**	**89440 (41 % loss)**

Table 151 : Effect of wet spell on yield of groundnut during *kharif* 2011

Variety	Flowering			Pegging			Pod development		
	Rain-fall	Rainy days	Sunshine hr	Rain-fall	Rainy days	Sunshine hr	Rain-fall	Rainy days	Sunshine hr
K6 Narayani TMV2	17	4	16.1	72.2	6	10.4	41.2	3	35.8
K6 Narayani TMV2	63.6	5	14.8	61.8	4	9.8	94.6	3	49.4
K6 Narayani TMV2	72.2	6	10.4	35.6	2	15.4	94.6	3	53.9
K6 Narayani TMV2	61.8	4	9.8	27	1	24.4	112.6	5	51.8
K6 Narayani TMV2	27	1	18.8	5.6	1	20.4	112.6	5	50.7

c. On-farm experiments

Village profile

The program is implemented by AICRPDA Centre, Anantapur, in Aminabad and Girigetla villages in Thuggali Mandal, Kurnool district, Andhra Pradesh. The total cultivated area is 167.5 ha out of which 123.4 ha is rainfed. The mean annual rainfall is 620 mm with seasonal rainfall of 190.4 mm during *kharif* (June-September).

Climate Variability in General

The climate in this agro-climatic zone is semiarid. Out of the total annual average rainfall of 342.9 mm, the south-west monsoon contributes 55.5%, north-east monsoon 26 % and summer 18.5%. For the past 15 years, the dry spells during crop season are experienced in August and October and at peg penetration, pod filling, pod development and harvesting stages of groundnut and flowering to reproductive stages in other crops. The onset of the monsoon had been shifting (onset being in 25 SMW and withdrawal 42-43 SMW). The soil moisture status is deficit during pod filling and pod development stages of groundnut.

Experienced weather conditions during the year (2011-12)

The villages received 342.9 mm which was deficit compared to normal 620 mm during south-west monsoon (Fig. 108). The onset of monsoon was normal). The crops experienced dry spells during pod filling and pod development stages during September i.e. during 36, 37, 38 & 39 SMWs. The intense rainfall event was experienced on 16-8-2011 with 51.2mm rainfall during crop growing season in *kharif*. This event triggered *Botrytis* incidence in castor.

Fig. 109a : Conservation furrow for in situ moisture conservation in castor

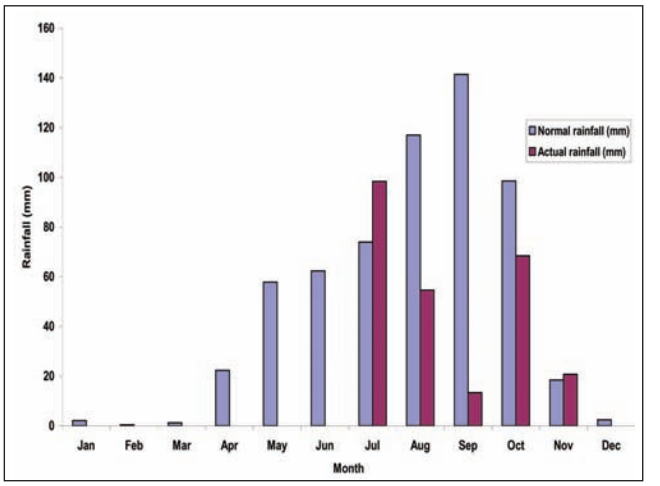

Fig. 108 : Normal and actual (2011) monthly rainfall at Aminabad Village

Interventions

The major interventions implemented included land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 295.2 ha in 420 farmers' fields.

Land configuration

The land configuration included conservation furrow in castor (Fig. 109a), which facilitated runoff modulation and enhanced *in-situ* moisture conservation, thus mitigated dry spell and enhanced the castor seed yield and RWUE by 1.3 to 1.7 compared to farmers' practice (1 to 1.5) (Fig. 109b) (Table 152).

Fig. 109b : Farmers' practice

Table 152 : *In situ* moisture conservation with conservation furrow in castor (Mean of 40 locations)

Crop	Variety	Yield (kg/ha)		% increase	RWUE (kg/ha/mm)	BC ratio
		Improved practice	Farmers' practice			
Castor	PCH-111	549.5	478.8	14.7	1.7	2.4
	GCH-4	421.6	341.5	23	1.3	1.3

Realtime contingency planning

Groundnut is the major conventional *kharif* crop in red soils of NICRA village Girigetla, Thuggali Mandal, Kurnool district. Farmers in the district normally sown pear millet in July-August in red soils. To develop climate resilient alternative cropping systerms, introduced pearlmillet + pigeonpea (5:1) intercropping system (Fig. 109c) for which sowing was taken up during second week of June 2011 as early sown intercrop and last week of July 2011 as normal sown crop. The early sown pearl millet crop (second week of June 2011) gave a grain yield of 750 kg/ha while the normal sown pear millet crop failed when sown during last week of July 2011 due to moisture stress at knee high stage. Pigeonpea gave an yield of 625 kg/ha.

Fig. 109c : Performance of early sown pearlmillet, as contingency strategy, in pigeonpea + pearlmillet intercrooping systems (5:1)

The drought tolerant varieties of castor (PCH-111), groundnut (K-6 and Narayani), chickpea (NBEG-3, Vihar and Jaki), pearlmillet (ABH-1) and setaria (Srilaxmi) during *kharif* were introduced to cope with the rainfall variability of the region (Fig. 110a to f) (Table 153).

Rainwater harvesting and recycling

A farm pond size of 10 x10 x 2.5m with the capacity of 250 m^3 was dug for efficient rainwater harvesting and recycling. The stored water in the farm pond was efficiently utilized for supplementary irrigation of 10 mm during seed development and pod development stages of the castor crop and groundnut (Fig. 111a, 111b) respectively. This enhanced the yield by 20 % and 46% in castor and groundnut respectively (Table 154).

(Mean of 8 locations)					
Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved practice	Farmers' practice		
Castor	PCH-111	471.0	350.0	34.0%	2.3
Groundnut	K-6	467.0	390.0	19.0%	1.3
	Narayani	427.0	390.0	9.4%	1.2
Chickpea	NBEG-3	589.7	471.8	24.0%	1.5
	Vihar	618.1	471.8	31.0%	2.1
	Jaki	806.5	471.8	70.0%	3.3
Pearlmillet	ABH-1	630	512	22.9%	1.6
Setaria	Srilaxmi	80	61	31.0%	1.6

Fig. 110a : Castor PCH-111

Fig. 110b : Castor -Local

Fig. 110c : Groundnut- K-6 (Improved practice)

Fig. 110d : Griundnut-TMV-2 (Farmers practice)

Fig. 110e : Chickpea improved variety - Vihar

Fig. 110f : Chickpea -Local variety

Fig. 110 (a to f) : Performance of improved varieties of castor, groundnut and chickpea

Table 154 : Efficient utilization of harvested rainwater of supplemental irrigation in groundnut

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net returns (Rs/ha)	BC ratio
		supplementary irrigation/ Life saving irrigation	Without irrigation			
Castor	GCH-4	410	341.5	20%	7570	1.7
Groundnut	TMV-2	683	467.0	46%	13811	1.9

Fig. 111a : Performance of castor and groundnut with supplemental irrigation

Fig. 111b : Performance of castor and groundnut without supplemental irrigation

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements viz. tractor drawn Ananta planter, bullock drown automatic seed drill and groundnut wet pod thresher were made available which not only saved labour and facilitated timely sowing but also gave higher output energy and higher returns compared to normal implements (Table 155). Sowing of groundnut with tractor drawn Ananta Planter (Fig. 112a) gave higher energy output and net returns than the farmer's practice (Fig. 112b).

Table 155 : Performance of implements in groundnut

Implement	Crop	Variety	Energy (MJ) for improved implement		Energy (MJ) for normal implement		Net returns (Rs/ha)	BC ratio
			Input	Output	Input	Output		
Tractor drawn Ananta planter	Groundnut	K-6	2561.6	2690	2339	3078	9817	1.76
Bullock drawn automatic seed drill	Groundnut	TMV-2	2269.66	2690	2339	3078	6232	1.41

Fig. 112a : Sowing of groundnut Tractor drawn Ananta planter

Fig. 112b : Farmers' practice

1.7.2 RAJKOT

a. Agro-ecological setting

Rajkot is located in Western plain, South Kachchh and north Kathiawar peninsular (AESR 2.4). The climate is hot arid.Average annual rainfall is 590 mm.

b. On-station experiments

At Rajkot, the onset of monsoon was during second week of July i.e. two weeks delayed. It withdrew on 22nd September. A rainfall of 1142.2 mm was received during cropping period as against the normal of 582.4 mm in 2011. August, September and October months received an excess rainfall to an extent of 247.5, 355.2 and 2170%, respectively over normal rainfall. However, June and July months received a deficit rainfall of 81.5 and 99.5 per cent respectively. Further, November and December months did not receive any rainfall (Fig. 113).

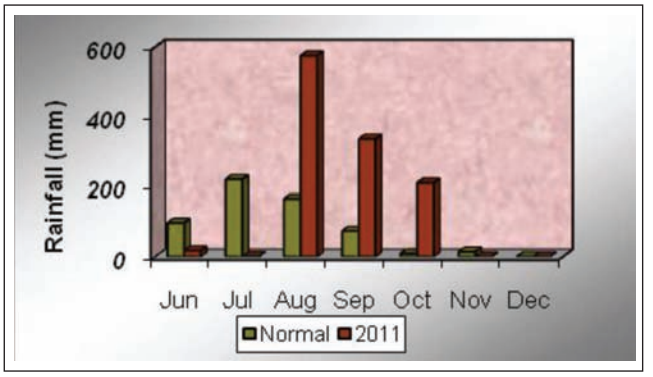

Fig. 113 : Normal and actual (2011) monthly rainfall at Rajkot

Real time contingency crop planning

In cotton and sesame, maximum income (Rs.142303/ha), net returns (Rs.101303/ha) and BC ratio (2.47) was recorded when cotton crop planted at120X45 cm and sesame at 60X20cm spacings (Table 156).

In both the normal as well as in delayed on set of monsoon, sole castor recorded higher net returns (54314 and 54647 Rs./ha) followed by groundnut + castor cropping system (Rs.28514 and 33496 /ha) respectively (Table 157).

Alternate land use system

At on-station, guava and citrus based agri-horti systems with groundnut were demonstrated. These interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies. In case of agro-horti system, the higher net returns (Rs. 32875 /ha) and BC ratio (2.19) was obtained when groundnut intercropped with guava in comparison to blackgram (Table 158).

Table 156 : Effect of planting geometry in cotton-sesame intercroping system on productivity and economics under late onset of monsoon

Spacing (cm)	Yield kg/ha		Income Rs/ha	Net return Rs/ha	BC ratio
	Cotton	Sesame			
120x30 60x10	3202	111	133918	92918	2.27
120x45 60x10	2435	130	104221	63221	1.54
120x60 60x10	2269	167	99499	58499	1.43
120x30 60x20	2824	46	115403	74403	1.81
120x45 60x20	3473	65	142303	101303	2.47
120x60 60x20	2296	102	97207	56207	1.37
90x30 45x10	3185	94	132376	91376	2.23
90x45 45x10	2815	110	118387	77387	1.89
90x60 45x10	2148	142	93371	52371	1.28
90x30 45x20	3408	39	138373	97373	2.37
90x45 45x20	2954	55	121050	80050	1.95
90x60 45x20	1963	87	83070	42070	1.03

Table 157 : Performance of intercroping systems under normal and delayed onset of monsoon situations

Tr.No.	Cropping system	Yield kg/ha		Cost of cultivation Rs./ha	Income Rs./ha	Net returns Rs./ha	BC ratio
		Main	By product				
Normal onset of rain (12 July,2011)							
T-1	Groundnut sole)	935	3982	20057	45675	25618	1.28
T-2	Castor (sole)	1296	5556	15414	69728	54314	**3.52**
T-3	Sesame (sole)	48	111	15414	1719	-13695	-0.89
T-4	Groundnut +	375	4352	18897	47411	28514	1.51
	Castor (3:1)	556	2315				
T-5	Groundnut +	441	2963	16889	28141	11252	0.67
	Sesame (2:1)	57	232		45675	25618	1.28
Delayed on set of monsoon (29 July, 2012)							
T-6	Groundnut (sole)	833	2871	20057	38498	18441	0.92
T-7	Castor (sole)	1945	6667	15414	70061	54647	**3.55**
T-8	Sesame (sole)	1096	2315	15414	38100	22686	1.47
T-9	Groundnut +	463	1852	18897	52393	33496	1.77
	Castor (3:1)	833	3334				
T-10	Groundnut +	648	4815	16889	45536	28647	1.70
	Sesame (2:1)	609	1389				

Table 158 : Performance of guava based agri-horti system

Crop	System	Yield (kg/ha) Crop	RWUE (kg/ha/mm)	Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	Net Returns (Rs/ha)	BC Ratio
Guava	Agri-horti	2003	0.40	16100	15000	32875	2.19
+ G nut		800	1.75	32875			
Guava +		2003	0.40	16100	13500	18200	1.34
Blackgram		460	0.70	15600			

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Rajkot in Pata Meghpar village Kalavad Taluka, Jamnagar district, Gujarat. The total cultivated area is 2793 ha out of which 1675 ha is rainfed. The mean annual rainfall is 585 mm with seasonal rainfall of 585 mm during *kharif* (June-September). The major soil types are medium black soils.The major rainfed crops during *kharif* are groundnut, cotton, sesame and during *rabi* are wheat, cumin, fenugreek and chikpea. The numbers of small, marginal, medium and large farmers are 28.7, 27.3, 27.8 and 16.1 per cent, respectively. The ground water table is 19.5 m below surface. The source of irrigation is open wells and bore wells covering 40.5 % of cultivated area.

Climate Variability in General

The climate in this agro-climatic zone is semi arid. Out of the total annual average rainfall of 585 mm, the south-west monsoon contributes 70-80 %. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 62.5 % of the average rainfall. The normal onset of monsoon is 26 SMW and withdrawal is on 39th SWM. However, for the past 10 years, the onset (south-west) of monsoon was during 27th SMW. The dry spells during crop season were experienced for the past 30 years at an interval of 10 years are given as under (Table 159).

The dry spells were experienced during peg formation and pod development stages in groundnut, square and boll formation stages in cotton and flowering and pod development stages in pulses. The onset of the monsoon is normally on 26th SMW of June (past 30 years). The maximum/minimum temperature (average) during crop season was 32.3 and 25ºC, respectively which is more or less remain similar during past 10 years. The extreme events like unusual and high intensity rainfall in shorts pan are increasing 32nd and 35th SMW of August during *kharif* season. Based on 53 years data, the probably extreme events like cold wave during 3rd SMW (January) and heat wave during 21st SMW (May) in the area. There has been considerable shift in rainfall pattern, in past 10 years rainfall received 895 mm which was excess by 67.5 percent *as* compared to normal 585 mm of the area and crops experienced dry spells during 33-34th SWM of August (mid season) and 37-38th SMW of September (later season). The start of monsoon during 2001-10 is 27th SMW instead of 28th SMW during 1991-00. Similarly, withdrawal of monsoon has also followed same trend which is 40th SMW during 2001-10 as compared to 41st SMW during 1991-00.

Experienced weather conditions during the year (2011-12)

The village received 895 mm which was excess of 340 mm compared to normal 585 mm during south-west monsoon (*kharif*) (Fig. 114). The onset of monsoon was delayed by two weeks (9th July 2011). The crops experienced mid season dry spells during 33 to 34 SMW (13 to 26 August) and terminal drought during 37 to 38 SMW (10 to 23 September) at flowering stage of groundnut and vegetative stage of cotton. The intense rainfall events in the village was experienced on 1st August 2011 (102 mm) due to which the sesame crop failed wherein the farmers were advised to take up re-sowing with castor.

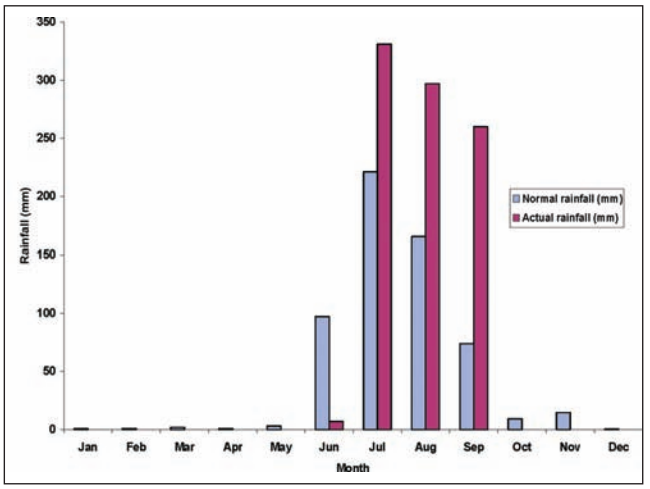

Fig. 114 : Normal and actual (2011) monthly rainfall at Pata Meghpar village

Interventions

The major interventions were implemented include land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 46 ha in 160 farmers' fields.

Land configuration

The land configuration included ridge and furrow system in groundnut (Fig. 115a) which facilitated runoff modulation, improved the drainage during extreme rainfall event (95 mm) on 9th July 2011 and enhanced *in situ* moisture conservation. This resulted in mitigating dry spells during critical stages of groundnut and blackgram and enhanced the crop yield 3.7 and 11.1 % , respectively and also the RWUE by 1.90 and 1.15 kg/ha/mm in groundnut and blackgram as compared to farmers practice (flat bed planting) respectively (Fig. 115b) (Table 159).

Crops/ Varieties/Cropping system

The drought tolerant varieties of groundnut (GG 20), sesame (G.Til 3), Bt cotton and castor (GCH 7) during

Table 159 : Performance of groundnut and blackgram under ridge and furrow system under delayed onset of monsoon and mid season droght

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha/mm)	BC ratio
		Ridge and furrow system	Flat bed planting			
Groundnut	GG20	1186	1144	3.7	1.90	1.05
Blackgram	Urad -1	1027	925	11.1	1.15	0.90

Fig. 115a : Ridge and furrow system in Groundnut

Fig. 115b : Flat bed planting in Groundnut

kharif and wheat (366) and fenugreek (G F), cumin (GC 4) and chickpea (G Gram 3) during *rabi* were introduced to cope with the rainfall variability of the region (Table 160).

The package include drought tolerant varieties with nutrient and pest management practices viz. in groundnut: castor cake 500 kg/ha, tricoderma powder 2.5 kg/ha, PSB 500 ml, azotobactor 500ml, sulfur granules 5kg; in Bt Cotton: Castor cake 500 kg/ha, tricoderma powder 2.5 kg/ha, nimazel 200 ml, blue copper 500g, citric acid 10 g and cotton seed 1kg; in Cumin: Castor cake 500 kg/ha menkozeb 1.5 kg/ha 200 gm/ha; in Black gram: Castor cake 500 kg/ha, tricoderma powder 2.5 kg/ha, black gram seed-25 kg; in Garlic: Tricoderma powder 2.5 kg/ha, PSB 500ml, azotobactor 500ml; in chickpea - Castor cake 500 kg/ha, PSB 500 ml kg/ha; in Wheat: Castor cake 500 kg/ha, tricoderma powder 2.5 kg/ha. PSB 500 ml kg/ha, zinc sulphate 250 kg/ha azotobactor 500 kg/ha and in Fenugreek: Castor cake 500 kg/ha menkozeb 1.5 kg/ha 200 gm/ha.

Rainwater harvesting and recycling

A farm pond size of 22 m x 21 m x 6 m with the capacity of 2772 m^3 was dug for efficient rainwater harvesting and recycling. The existing farm pond in the village is of size 14 m x 11 m x 2 m was also renovated. The harvested rainwater in the farm pond was efficiently utilized for supplementary irrigation of 5 cm during critical stages of the groundnut and cotton crops. In cotton, supplemental irrigation is given through drip system (Fig. 116 a to c) (Table 161).

Table 160 : Performance of crop management practices in rainfed crops under delayed onset of monsoon and mid season droght

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved practice	Farmers' practice		
Kharif					
Groundnut	GG 20	1703	1510	12.8	1.23
Cotton	Bt cotton	3229	3013	7.2	1.20
Black gram	Urad -1	1027	915	12.2	1.27
Rabi					
Wheat	GW 366	4152	3906	6.3	1.20
Fenugreek		2056	1832	12.2	1.59
Cumin	GC 4	680	545	24.7	1.93
Gram	G Gram 3	1853	1500	23.5	2.43

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The improved implements made available include rotavator, cultivator, M.B. plough, land leveler which gave higher output energy and crop yield compared to normal implements. The rotavator was used for *in situ* composting (Fig. 117 a to c) of cotton stalks in groundnut crop resulting in higher energy output and higher groundnut yield. Custom hiring services significantly contributed to alleviate labour shortage during peak demand period (Table 162).

Table 161 : Performance of groundnut and cotton under supplemental irrigation

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net returns (Rs/ha)	BC ratio
		Supplementary irrigation	Without irrigation			
Groundnut	GG-20	1825	1450	25.8	16875	1.78
Cotton	Bijdhan BG II	3475	2850	21.9	28125	1.24

Fig. 116a : Lifting of water from farm pond

Fig. 116b : Groundnut with supplemental irrigation

Fig. 116c : Supplemental irrigation through drip system in cotton

Fig. 116 (a to c) : Packaging efficient utilization of harvested rainwater in Pata Meghpar village

Table 162 : Efficient crop residue recycling with rotavator

Implement	Crop	Variety	Energy(MJ/ha)		Yield (kg/ha)		Net returns (Rs/ha)	BC ratio
			With improved practice*	Farmers' practice	Improved practice	Farmers' practice		
Rotavator	Groundnut	GG 20	557.2	251.2	1735	1622	4294	1.13

* ***In situ*** **composting of cotton stalks**

Fig. 117a : Incorporation of cotton stalks with rotavator

Fig. 117b : *In situ* composting of cotton stalks

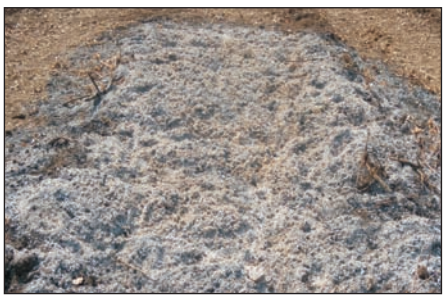

Fig. 117c : Farmers' practice

1.8. Cotton Based Production System

1.8.1 AKOLA

a. Agro-ecological setting

Akola is in Eastern Maharashtra of Deccan Plateau, hot semi-arid eco-region (AESR 6.3). The climate is hot moist semi-arid. Average annual rainfall is 825 mm. Length of growing period is 120-150 days.

b. On-station experiments

At Akola, the onset of monsoon was during last week of June, which was delayed by 30 days. A rainfall of 464.3 mm was received during cropping period of 2011 as against normal of 770.2 mm. However, all the months received a deficit rainfall as compared to their normal rainfall values. Months like June, July, August, September and October received a deficit rainfall to the tune of 46, 21.7, 41.3, 20.3 and 96.3 per cent, respectively (Fig. 118). Further, both November and December months did not receive any rainfall.

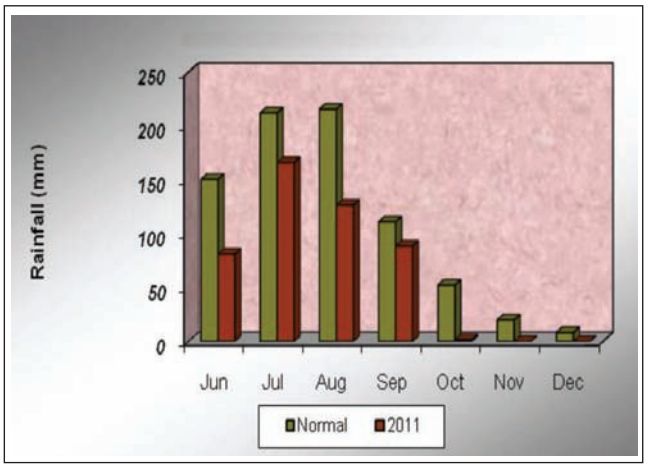

Fig. 118 : Normal and actual (2011) monthly rainfall at Akola

Alternate land use systems

During *kharif* 2011, custard based and Hanumanphal based agri-horti-systems were demonstrated. Maximum BC ratio was recorded in custard apple + greengram + pigeon peasystem (Table 163 & 164).

Table 163 : Performance of custard apple based agri-horti system

Treatments	Rainfall (mm)	Duration of crops 1 & 2	Yield (kg/ha) Y1+ Y2	Custard apple equivalent yield (kg/ha)	RWUE (kg/ha/ mm)	Cost of culti-vation (Rs./ha)	Gross returns (Rs./ha) from C1 and C2	NMR (Rs/ ha)	BC ratio	LER
Custard apple + fallow	-	-	-	-	-	8870	-	-8870	-	-
Custard apple + sole greengram	324.2	66	306	398	0.94	14162	12203	-1959	0.86	1.00
Custard apple + sole blackgram	327.7	85	176	187	0.54	14032	5734	-8298	0.41	1.00
Custard apple + sole soybean	328.5	95	766	551	2.33	17457	17108	-349	0.98	1.00
Custard apple + sole pigeonpea	329.4	168	336	363	1.02	17353	11432	-5921	0.66	1.00
Custard apple + greengram + pigeonpea (2:1)	329.4	66 168	579 (278+301)	687	1.76	16242	21293	5051	1.31	1.80
Custard apple + blackgram + pigeonpea(2:1)	329.4	85 168	293 (126+167)	314	0.89	15847	9837	-6010	0.62	1.21
Custard apple + soybean + pigeonpea (2:1)	329.4	95 168	752 (508+244)	629	2.28	19763	19618	-145	0.99	1.39

Table 164 : Performance of hanuman phal based agri-horti system

Treatments	Rainfall (mm)	Duration of crops 1 & 2	Yield (kg/ha) Y1+ Y2	Hanuman Phal equivalent yield (kg/ha)	RWUE (kg/ha/ mm)	Cost of culti-vation (Rs./ha)	Gross returns (Rs./ha) from C1 and C2	NMR (Rs/ ha)	BC ratio	LER
Hanuman phal + Fallow			-		-	8870	-	-8870	-	-
Hanuman phal + sole greengram	324.2	66	191.1	249.2	0.59	14162	7632	-6530	0.54	1.00
Hanuman phal + sole blackgram	327.7	85	154.7	164.0	0.47	14032	5029	-9002	0.36	1.00
Hanuman phal + sole soybean	328.5	95	309.4	222.3	0.94	17457	7120	-10337	0.41	1.00
Hanuman phal + sole Pigeonpea	329.4	168	231.3	250.2	0.70	17353	8150	-9202	0.47	1.00
Hanuman phal + greengram + pigeonpea(2:1)	329.4	66 168	284.2 (140.2+144)	338.5	0.86	16242	10510	-5732	0.65	1.36
Hanuman phal + blackgram + pigeonpea(2:1)	329.4	85 168	278.4 (116.6+ 161.8)	298.7	0.85	15847	9310	-6538	0.59	1.45
Hanuman phal + soybean+ pigeonpea(2:1)	329.4	95 168	379.6 (173.7+ 205.9)	347.4	1.15	19763	10990	-8784	0.56	1.45

c. On-farm experiments

Village profile

The program is implemented by AICRPDA Centre, Akola in Warkhed (Bk) village, Barshi Takali Taluka, Akola district, Maharashtra. The total cultivated area is 275 ha out of which 252 ha is rainfed. The mean annual rainfall is 796.0 mm with seasonal rainfall of 743 mm during *kharif* (June-September). The major soil types are shallow, medium deep, deep and very deep black soils. The major rainfed crops during *kharif* are cotton, soybean, greengram, sorghum and pigeonpea and during *rabi* is chickpea. The number of small, marginal, medium and large farmers are 84, 84, 29 and 1, respectively. The groundwater table is 7.8 m below ground. The source of irrigation are open wells and bore-wells covering 8.36% of cultivated area only.

Climate Variability in General

In general, the climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 818 mm, the south-west monsoon contributes 84%, post monsoon 9%, winter 3% and summer 4%. The historical rainfall data (last 30 years) indicated that the variability in rainfall during south-west monsoon was deficit with -16% of the average rainfall. The onset (south-west) of monsoon is during 24th SMW and post monsoon rains were uncertain. For the past 10-15 years, dry spells are being experienced during July, August and September coinciding with the vegetative or reproductive stages of the major rainfed crops. The onset of the monsoon was sometimes delayed upto 25th SMW and 26th SMW and early withdrawal observed during 39th SMW. The soil moisture status was often deficit during reproductive stages of major rainfed crops, particularly cotton and pigeonpea. The maximum/minimum temperature during crop season

showed insignificant increasing trend of maximum (+0.05^{o}C/year) and minimum (+0.08^{o}C/year) for *kharif* season and insignificant decreasing trend of maximum (-0.02^{o}C/year) and increasing trend of minimum temperature (+0.1^{o}C/year) for *rabi* season for the past 10 years. The extreme events like unusual and high intensity rainfall in short span were decreasing during *kharif* and *rabi* seasons. The area has also been experiencing other extreme events like cold wave normally during second fortnight of December to first fortnight of January. There had been shift in rainfall pattern with decadal trend showing a decrease in June and July rainfall in the last two decades and increase in September rainfall during the same period.

Experienced weather conditions during the year (2011-12)

The village received 640 mm rainfall which was deficit by 103.6 mm compared to normal (743.6 mm) during south-west monsoon (*kharif*) (Fig. 119). The onset of monsoon was delayed by 7 days. The crops experienced dry spells during reproductive stage in September during 38th and 39th SMW impacting the performance of cotton and soybean crops. During *kharif*, maximum temperature remained mostly below normal with deviation of -0.2 to -2.5ºC while during post monsoon and early winter, it remained above normal by 1.0 to1.8^{o}C.

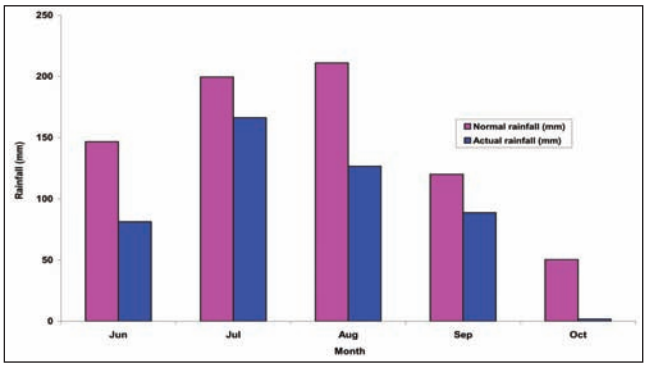

Fig. 119 : Normal and actual (2011) monthly rainfall at Warkhed Village

Interventions

The major interventions implemented include land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 20.8 ha in 52 farmers' fields.

Land configuration

The land configuration included furrow opening at 30 days after sowing in between crop rows of cotton (Fig. 120a) which facilitated runoff modulation and enhanced *in-situ* moisture conservation. This resulted in mitigating dry spell and enhanced the crop yield by 5.22% and rainwater use efficiency by 4.84% compared to farmers practice (Fig. 120b) (Table 165).

Table 165 : In situ moisture conservationwith opening furrow at 30 DAS in cotton

Crop	Variety	Yield (kg ha^{-1})		% increase in yield	RWUE (kg ha^{-1} mm^{-1})	BC ratio
		Furrow opening at 30 DAS	Farmers' practice			
Cotton	NCS-145	1250	1188	5.22	1.95	1.86

Fig. 120a : Furrow opening in cotton at 30 DAS

Fig. 120b : Farmers' practice (No furrow opening)

Crops/Varieties/Cropping system

During *kharif,* the drought tolerant varieties of sorghum (CSH-14) and cotton + greengram (1:1) (Fig. 121a, b), greengram+ pigeonpea (4:2) and soybean+ pigeonpea (4:2) intercropping systems were introduced with suitable varieties viz. JS-335 (soybean), PKV Tara (pigeonpea) and Green Gold (greengram) for risk minimization in view of rainfall variability of the region (Table 166).

Table 166 : Performance of improved varities of rainfed *kharif* crops and cropping systems under mid season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio
		Improved varieties	Local varities		
Sorghum	CSH-14	1953	1875	4.13	1.75
Cotton + greengram (1:1)	Bt Cotton Greengram: Green gold	1841	1188	4.97	2.18
Greengram+ pigeonpea (4:2)	Greengram: Green gold Pigeonpea: PKV Tara	1036	750	38.07	2.45
Soybean+ pigeonpea (4:2)	Soybean: JS 335 Pigeonpea: PKV Tara	1163	1095	9.00	1.40

Fig. 121a : Cotton + greengram (1:1) intercropping

Fig. 121b : Sole Cotton

Rainwater harvesting and recycling

Two existing farm ponds in the village of size 20 m x 20 m x 3 m were renovated. There was no storage of water in the farm pond during this year due to deficit rainfall.

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The PTO operated multipurpose thresher (Fig. 122) is being used by the farmers for soybean threshing. The multipurpose thresher was also made available at this centre.

Alternate land use and Eco-system services

At on-station, *Annona squamosa* and *Annona atemoya* based agri-horti system with soybean, greengran, blackgram and pigeonpea as intercrops were demonstrated. Agroforestry, agro-horti and other carbon capture systems help in both adaption and mitigation. Hence, these interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies.

Fig. 122 : Multipurpose thresher hired by the farmer for value addition

1.8.2. KOVILPATTI

a. Agro-ecological setting

Kovilpatti is in Tamil Nadu Uplands and leeward flanks of South Sahayadris and Deccan (Karnataka) plateau (*AESR 8.1*). The climate is hot semi-arid. Length of growing period is 90-120 days.

b. On-station experiments

A rainfall of 647.2 mm was received during cropping period of 2011 as against normal of 464 mm. An excess rainfall was received during August, September, October and November to an extent of 18.1, 1146, 15.8 and 88 per cent, respectively when compared to normal rainfall. However, months like June, July and December received a deficit rainfall of 54.9, 71.7 and 68 per cent, respectively (Fig. 123).

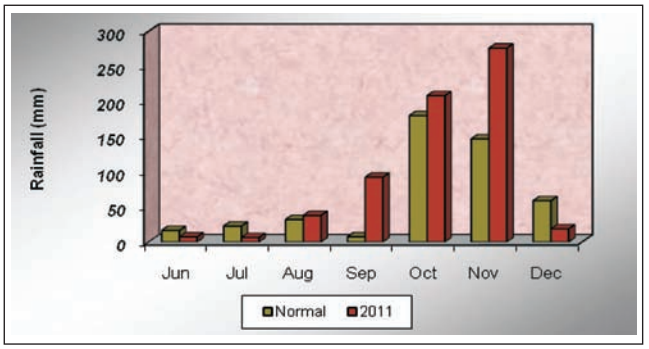

Fig. 123 : Normal and actual (2011) monthly rainfall at Kovilpatti

Real time contingency crop planning

During *kharif* 2011, the location experienced both excess and deficit rainfall during crop growing season. Improved varieties of various crops were evaluated.

Evaluation of drought tolerant varieties/ hybrids of different crops

a) Cotton

RCH 530 recorded significantly higher yield with a BC ratio of 2.04 and rain water use efficiency of 3.30 kg/ ha/mm (Table 167).

b) Maize

There was a deficit rainfall of 68 per cent during December. However, maize hybrids 900 M Gold registered significantly higher yield (6500 kg/ ha) with BC ratio of 2.86 (Table 168).

c) Greengram

Green gram cv. CO6 recorded significantly higher yield compared with CO7. The BC ratio was 2.85 and the rainwater use efficiency was 3.49 kg/ha mm (Table 169).

d) Blackgram

In blackgram the variety Nirmal recorded significantly higher yield (1250 kg/ha) with BC ratio of 2.22 and the rainwater use efficiency of 2.64 kg/ha/mm (Table 170).

Table 167 : Performance of Bt cotton under aberrant rainfall (excess and dificit) condition

Hybrid/ variety	Rain fall (mm)	Crop duration (Days)	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ ha)	Gross returns (Rs/ ha)	Net returns (Rs/ ha)	BC Ratio
RCH 530	563	165	1860	40.00	3.30	36500	74400	37900	2.04
Jackpot	563	165	1610	41.49	2.86	33500	64400	30900	1.92
Tulasi 117	563	165	1725	40.82	3.06	35500	69000	33500	1.94
Mallika	563	165	1575	40.65	2.80	34500	63000	28500	1.83

Table 168 : Performance of maize varieties/ hybrids under aberrant rainfall (excess and deficit) condition

Hybrid/ variety	Rain fall (mm)	Crop duration (Days)	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ ha)	Gross returns (Rs/ ha)	Net returns (Rs/ ha)	BC Ratio
900 M Gold	482	110	6500	40.82	13.49	25000	71500	46500	2.86
Sunny	482	110	5000	41.67	10.37	24500	55000	30500	2.24
COH (M) 5	482	110	4800	40	9.96	27000	52800	25800	1.96

Table 169 : Performance of improved varieties of greengram under aberrant rainfall (excess and deficit) condition

Hybrid/ variety	Rain fall (mm)	Crop duration (Days)	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
CO 6	473	75	1650	34.48	3.49	19700	56100	36400	2.85
CO 7	473	75	1400	33.9	2.96	19200	47600	28400	2.48

Table 170 : Performance of improved varieties of blackgram under aberrant rainfall (excess and deficit) condition

Hybrid/ variety	Rain fall (mm)	Crop duration (Days)	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
VBN 4	473	75	1150	34.25	2.43	18700	40250	21550	2.15
Nirmal	473	75	1250	33.67	2.64	19700	43750	24050	2.22
CO 5	473	75	1180	33.78	2.49	19300	41300	22000	2.14

e) Pearlmillet

In pearlmillet, 80 M 32 registered significantly higher yield (2250 kg/ha) compared with CO (Cu) 9 and CO 9. The BC ratio was 2.57 and the rainwater use efficiency was 5.75 kg/ha/mm (Table 171).

f) Sunflower

In sunflower, variety CO(SFV)5 recorded significantly higher yield than the hybrid frontline (Table 172).

Evaluation of different intercropping systems:

Bt cotton + green gram registered higher cotton equivalent yield (1001 kg/ha), gross return Rs.40,075/ha, net return of Rs. 13675/ha higher BC ratio 1.52, RWUE with 1.89 and increase LER 1.46. Among the four pulses, Bt cotton + redgram observed lower cotton equivalent yield 836.7 kg/ha (Table 173).

Rainwater harvesting (*in-situ* and *ex-situ*) and efficient use

Adoption of broadbed furrow (BBF) technique for *in situ* moisture conservation resulted in 8.0, 5.2, 9.8 and 7.6 percent increased yield in maize, cotton, greengram and blackgram, respectively. Due to the increased moisture level in broad bed furrow treatment when compared to the ridges and furrow in maize and cotton and flat sowing in green gram and black gram. The increased soil moisture storage in BBF might be due to the loosening of soil during the intercultivation operation thus resulting in easy movement of rain water into the soil profile (Table 174).

Table 171 : Performance of improved varieties of pearlmillet

Hybrid/ variety	Rain fall (mm)	Crop duration (Days)	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
CO (Cu) 9	391	90	1840	40.82	4.71	10500	22080	11580	2.10
80 M 32	391	90	2250	41.67	5.75	10500	27000	16500	2.57
Co 9	391	90	2000	40.65	5.12	10000	24000	14000	2.40

Table 172 : Performance of improved lines of sunflower

Hybrid/ variety	Rain fall (mm)	Crop duration (Days)	Yield (kg/ha)	Harvest Index	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC Ratio
Frontline	285	90	1340	42.19	4.70	20500	45000	24500	2.20
CO (SFV) 5	285	90	1500	41.67	5.26	16500	40200	23700	2.44

Table 173: Performance of different intercropping systems under aberrant rainfall (excess and deficit) condition

Intercropping system with row ratios (1:1)	Rainfall (mm)*	Duration of Crop 1 & 2 (days)		Yield (kg/ha)		RWUE (kg/ha/mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha) from C_1 & C_2	Net returns (Rs/ha)	BC ratio	LER
		Cotton	Inter-crop	Cotton	Inter-crop						
Cotton + sole crop	530	165	-	907	-	1.71	25200	36280	11080	1.44	1.0
Cotton + blackgram	530	165	80	781	70	1.59	26150	33690	7540	1.29	1.22
Cotton + greengram	530	165	70	875	145	1.89	26400	40075	13675	1.52	1.46
Cotton + cowpea	530	165	75	807	189	1.83	27000	38895	11895	1.44	1.38
Cotton + pigeonpea	530	165	105	660	202	1.58	26800	33470	6670	1.25	1.40

Table 174 : Performance of crops with various land configuration under aberrant rainfall (excess and deficit) condition

Crop	Hybrid	Rain fall (mm) *	Type of *in-situ* conservation Technology	Per cent increase in soil moisture over control	Yield (kg/ha)	RWUE (kg/ha/mm)	Cost of Cultivation	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Maize	NK6240	504.2	Broad bed furrows	8.0	5250	10.41	24000	57750	33750	2.41
			Ridges and furrows		4870	9.66	25000	53570	28570	2.14
Cotton	Maha Mallika	512.4	Broad bed furrows	5.2	1730	3.38	32000	69200	37200	2.16
			Ridges and furrows		1680	3.28	32000	67200	35200	2.11
Greengram	CO 7	503.4	Broad bed furrows	9.8	1280	2.54	18000	44800	26800	2.50
			Ridges and furrows		1180	2.34	18000	41300	23300	2.30
Blackgram	VBN 4	503.4	Broad bed furrows	7.6	910	1.81	17500	32760	15260	1.87
			Ridges and furrows		850	1.69	17500	30600	13100	1.75

A farm pond of 29 x 20 x 2 m^3 dimension with capacity of 800 m^3 and catchment and command area of 3.2 ha and 0.5 ha, respectively was dug for rainwater harvesting and efficient utilization of stored water.

During *rabi* 2011, runoff occurred for 4 rainfall events on 15.10.2011, 17.10.2011, 4.11.2011 and 27.11.2011. The depth of water in the pond due to the rainfall of 51.6 mm on 15.10.2011 was 1630 mm. The increase in water level was 100 mm and 50 mm respectively for the rainfall events on 17.10.2011 and 4.11.2011. The pond became dry during the 47th SMW i.e., during November second fortnight. During this period, the crops did not experience moisture stress and hence supplemental irrigation was not given. Subsequent to the rainfall event on 27.11.2011 (134.8 mm), the pond filled to its full capacity (800 m^3). The pond got submerged and the depth of water stored was 210 mm as against the design depth of 200 mm. At the end of December 2011, the cotton crop at the flowering stage experienced terminal stress and the water available in the pond was used for giving supplemental irrigation. The

effective depth of storage was 450 mm (767 mm water level at the end of 52nd week) 100 mm (Dead storage) – Depth of silt (217 mm). The total volume of water available at the end of December 2011 was 180 m^3 (20x20x0.45 m). With 180 m^3 of stored water, supplemental irrigation was given to watermelon (0.1 ha), Bt cotton (0.1 ha) and periwinkle (0.1 ha) to a depth of 5 cm and the data are presented (Table 175).

The total volume of water available at the end of December 2011 was 180 m^3 (20x20x0.45 m). With 180 m^3 of stored water, supplemental irrigation was given to watermelon (0.1 ha), Bt cotton (0.1 ha) and periwinkle (0.1 ha) to a depth of 5 cm. The yield of cotton increased by 18.1 % with the BC ratio of 1.88 when compared to the unirrigated plot (Table 176).

Table 175 : Water storage details in farm pond

Weekly data		Depth of water in a pond (mm) (Water level at the start of the week)	Evaporation (mm)	Seepage loss (mm)
Farm pond 1 (On- station)				
Date	SMW			
Oct (16 – 22)	42	1630	2.66	22.18
Oct (23 – 29)	43	1501	1.49	23.01
Oct (30 – 05)	44	1293	1.19	12.31
Nov (06 – 12)	45	1248	2.73	49.77
Nov (13 – 19)	46	723	2.50	51.50
Nov (20 – 26)	47	199	2.47	22.53
Nov (27 – 03)	48	2100	1.46	21.19
Dec (04 – 10)	49	1877	2.46	35.54
Dec (11 – 17)	50	1496	2.33	38.17
Dec (18 – 24)	51	1096	2.13	31.87
Dec (25 – 31)	52	767	3.02	24.98
	Total		**24.44**	**333.05**

Table 176 : Performance of rainfed crops with supplemental irrigation from harvested rainwater

Crop	Variety	On-station	Rainfall (mm) from sowing to harvest	Water used for critical irrigation (cm)	Pond capacity (m^3)	Yield (kg/ha)	RWUE (kg/ha/mm)	Cost of cultivation (Rs /ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
Cotton	RCH BG II	Un irrigated	504.4	-	800 m^3	1575	3.12	37,500	63,000	25,500	1.68
		Irrigated	554.4	5 cm		1860	3.35	39,625	74,400	34,475	1.88
Periwinkle			Crop is in harvest stage								
Water melon			Crop sown on 30.11.2011 and the hybrid melon's yield was poor and the fruits were damaged by the squirrels and peacocks								

Alternate land use systems

In aonla based agri horti systems, cowpea, green gram and cluster bean were sown in the interspace of aonla. Among the three, cluster bean recorded highest vegetable yield of 1883 kg/ha. In custard apple based intercropping systems, green gram, bhendi and horsegram were sown in the interspace of custard apple. Among the three, bhendi recorded highest yield of 375 kg/ha. In sapota based intercropping systems, bitter gourd, pumpkin and coriander were sown in the interspace of sapota. Among the three, coriander recorded highest grain yield of 139 kg/ha (Table 177).

Table 177 : Performance of aonla, custard apple and sapota based agri-horti systems

Crop	Intercrop	Tree Crops (Variety)	Rainfall (mm)	Yield (kg/ha)		Crop duration (days)	RWUE (kg/ha/ mm)	Cost of cultivation (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	BC ratio
				Fruit	Crop						
Aonla	Sole	Krishna	604.6	-	-	perennial	-	-	-	-	-
	Greengram – CO 6	-	604.6	-	120	75	19.85	2500	4200	1700	1.68
	Cowpea- P 152	-	604.6	-	167	70	27.62	2600	5010	2410	1.93
	Cluster bean	-	604.6	-	1883	90	311.45	4300	9415	5115	2.19
Custard apple	Sole	PKM 1	604.6	-	-	perennial	-	-	-	-	-
	Green gram – CO 6	-	604.6	-	108	75	17.86	2400	3780	1380	1.58
	Bhendi	-	604.6	-	375	90	62.02	3500	3750	250	1.07
	Horse gram	-	604.6	-	112	70	18.52	2000	3360	1360	1.68
Sapota	Sole	PKM 1	604.6	-	-	perennial	-	-	-	-	-
	Bittergourd	-	604.6	-	95	90	15.71	2200	2850	650	1.30
	Pumpkin	-	604.6	-	100	90	16.54	1100	2300	1200	2.09
	Coriander - local	-	604.6	-	139	45	22.99	1200	3753	2553	3.13

c. On-farm experiments

Village profile

The program is implemented by AICRPDA centre, Kovilpatti in Nakkalamuthanpatti village, Kovilpatti Taluk, Thoothukudi district,Tamil Nadu. The total cultivated area is 630.65 ha out of which 578.83 ha is rainfed. The mean annual rainfall is 737.9 mm with seasonal rainfall of 512 mm during *rabi* 2011 (October - December). The major soil types are medium deep to deep black soils and red soils. The major rainfed crops during *rabi* are maize, greengram, blackgram, cotton and sunflower. The number of small, marginal and large farmers are 111, 368, 69 respectively. The ground water table is 800 cm. The source of irrigation is open dug wells, covering 15 % of cultivated area.

Climate Variability in General

The climate in this agro-climatic zone is semi-arid and north east monsoon season is the main cropping season under rainfed conditions in this zone. Out of the total annual average rainfall of 737.8 mm, the south-west monsoon contributes 20.1%, north-east monsoon 53.1% and summer 20.6%. The historical rainfall data indicated that the variability in rainfall during southwest monsoon season (in the last 30 years from 1972 to 2011) was 17.6% surplus compared to the average rainfall from 1901 to 1971 and while comparing the same periods it is found that rainfall during north east monsoon season is 5.9% surplus. The onset of south west monsoon is during 22nd SMW (1st June) and north east monsoon is 42nd SMW (20th October) in the state. The length of growing period spans from 38th SMW to 47th SMW. For the past 10 years, the dry spells during cropping season are experienced in the months of December and January (from 49th SMW to 4th SMW) which coincided with grain maturity stages of the major rainfed crops. The onset of the south-west monsoon and north-east monsoon, in the last ten years, was normal with a maximum deviation of ± 9 days. The soil moisture status was deficit during grain maturity stages of major rainfed crops. Maximum temperature during SWM and NEM season did not change in the last ten years (2002 – 2011) compared to the previous ten years (1992 – 2001); while comparing the same periods it was found that minimum temperature increased by 2.4 ^{o}C in both the seasons. The extreme events like unusual and high intensity rainfall in short span were experienced and did not impact *kharif* and *rabi* crops. No other extreme events were experienced in this area. There had been no shift in rainfall pattern and sowing window during NEM season; the sowing week is 37th SMW for the dominant rainfed crops.

Experienced weather conditions during the year 2011-12

The village received 503.4 mm which was 26.1% excess compared to the normal rainfall of 399.3 mm during north east monsoon season (*rabi)* (Fig. 124). The onset of monsoon was normal (24th October). The cotton crop experienced dry spells during 41st and 52nd SMW in 2011 and 1st to 13th SMW in 2012 except 6th and 11th SMW which coincided with boll opening, ripening and maturity stages. High rainfall event was experienced on 27.11.2011 with a rainfall of 138.4 mm (48th SMW) which benefitted the crops like maize and cotton. During the cropping period the maximum temperature was normal and cold wave was

experienced in 45th and 52nd SMW in 2011 and 3rd and 4th SMW in 2012 which coincided with squaring, blooming and boll opening stages of cotton and vegetative, grain filling and grain maturity periods of maize.

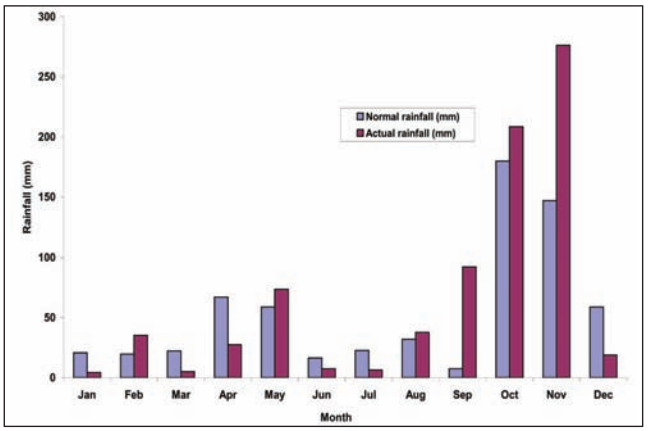

Fig. 124 : Normal and actual (2011) monthly rainfall at Nakkalamuthanpatti Village

Interventions

The major on-farm interventions implemented include land configuration, crops or varieties/cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 18.78 ha in 49 farmers' fields.

Land configuration

The land configuration included broad bed and furrows (Fig. 125a) (Width of bed: 1m, Depth and width of furrow: 30 cm) with tractor drawn ferti-seed drill and simultaneous sowing of seeds and fertilizers. This method was compared to the formation of ridges and furrows (Farmers practice) (Fig. 125b) and manual dibbling of seeds in cotton and maize crops. In pulses the BBF practice was compared to the farmers method of flat sowing. The BBF practice facilitated runoff modulation and enhanced *in situ* moisture conservation. This resulted in mitigating dry spell and enhanced the crop yield by 8.0, 0.8, 6.1, 9.0 per cent in maize, cotton, green gram and black gram and rainwater use efficiency by 8.9, 1.0, 6.0 and 8.6 % compared to farmers practice in maize, cotton, greengram and blackgram respectively. Further BBF also could provide better drainage in black soils during the excess rainfall event of 138.4 mm, thus benefitting both maize and cotton and also other crops (Table 178).

Table 178 : Performance of *in-situ* moisture conservation practices in *kharif* crops

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)		BC ratio
		Improved practice (Broad bed furrows)	Farmers' practice (Ridges and Furrow)		Improved practice	Farmers' practice	
Maize	Prabal	5093	4681	8.0	10.05	9.23	2.38
Cotton	RCH II Bt	1681	1667	0.8	3.04	3.01	2.02
Greengram	CO 7	1345	1267	6.1	2.67	2.52	2.37
Blackgram	VBN 4	942	865	9.0	2.01	1.85	1.81

Fig. 125a : Broad Bed and Furrow system in maize (Improved practice)

Fig. 125b : Ridges and Furrow system in maize (Farmers practice)

The drought tolerant varieties/ hybrids of rainfed crops viz. cotton, maize (private and CoH (M) 5, CoH (M)4), greengram (CO6, CO7, KM2, blackgram (VBN 4, Nirmal, CO 5, T 9 (check)), pearlmillet (CO (Cu) 9, 80M32, Co 9, sunflower (Front line, CO (SFV) 5, K 1) were introduced to cope with the rainfall variability of the region. Though the cotton crop experienced dry spells during 41st and 52nd SMW in 2011 and 1st to 13th SMW in 2012 except 6th and 11th SMW which coincided with boll opening, ripening and maturity stages, the improved cotton cultivars could yield better and the yield increase was up to 15 % over local checks (Table 179).

Rainwater harvesting and recycling

A farm pond of size 20 x 20 x 2 m and 800 m^3 capacity was dug for efficient rainwater harvesting and recycling (On - station). The stored water in the farm pond during this year was efficiently utilized for supplementary irrigation of 5 cm depth during maturity stages of the cotton crop (Fig. 126a). There was an increase in yield of 18.1% with supplemental irrigation in cotton compared to farmers practice of no supplemental irrigation (1575 kg/ha) (Fig. 126b) (Table 180).

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The wheel hoes were made available for interculture (Fig. 127a) and weeding in maize, cotton and pulses. These implements gave higher output energy and crop yield compared to normal implements. The wheel hoe reduced

Crops/ Varieties/Cropping system

Table 179 : Performance of improved varieties/ hybrids of *kharif* crops under normal onset of monsoon and mid season drought (cotton)

Crop	Variety	Yield (kg/ha)		% increase in yield	BC ratio	
		Improved practice	Farmers practice		Improved practice	Farmers' practice
Bt cotton	RCH 530 BG II	1860	1750	6.29	2.04	2.10
	Jackpot	1610	1450	11.03	1.92	1.95
	Tulasi 117	1725	1500	15.00	1.94	1.93
Maize	900 M Gold	6500	6250	4.00	2.86	2.46
	Sunny	5000	4750	5.26	2.24	2.05
	CO H (M) 5	4800	4500	6.67	1.96	2.00
Greengram	CO 6	1650	1500	10.00	2.85	2.47
	CO 7	1400	1250	12.00	2.48	2.13
Blackgram	VBN 4	1150	1000	15.00	2.15	1.71
	Nirmal	1250	1100	13.64	2.22	1.94
	CO 5	1180	1125	4.89	2.14	2.07
Pearlmillet	CO (Cu) 9	1840	1750	5.14	2.10	1.67
	80M32	2250	2000	12.50	2.57	2.00
	Co 9	2000	1640	21.95	2.40	1.82
Sunflower	Front line	1340	1250	7.20	2.20	2.00
	CO (SFV) 5	1500	1400	7.14	2.44	2.10

Table 180 : Performance of cotton with supplemental irrigation from the harvested rainwater

Crop	Variety	Yield (kg/ha)		Increase in yield (%)	Net returns (Rs/ha)		BC ratio	
		Supple-mental irrigation	Without irriga-tion		Supple-mental irrigation	Without irriga-tion	Supple-mental irrigation	Without irriga-tion
Cotton	RCH II	1860	1575	18.1	34,475	25,500	1.88	1.68

Fig. 126a : Supplemental irrigation in cotton using stored water in farm pond

Fig. 126b : Cotton without Supplemental irrigation

the drudgery compared to farmers practice (Fig. 127b) (Table 181).

Alternate land use and Eco-system services

Acid lime, aonla, sapota and custard apple based agri-horti systems with blackgram, green gram, pumpkin, cowpea, chickpea, coriander, horsegram, bittergourd, cluster bean, bhendi were demonstrated in farmers' fields. These interventions were made to educate farmers that climate change need to be tackled both short-term and long-term strategies.

Table 181 : Effective of interculture and weeding with wheel hoe in rainfed crops

Implement	Crop	Variety	Energy (MJ) for improved implement		Energy (MJ) for normal implement	Net returns (Rs/ha) with improved implement	BC ratio
			Input	Output	Input		
Wheel hoe	Maize	NK624	5694	8452	5812	38700	2.58
		Prabal	5650	9187	5768	46750	2.13
		RCH II	8682	4687	8800	37500	2.00
	Cotton	Bullet	8500	3750	8618	29000	1.94
		RCH II	8000	4375	8118	37500	2.15
		CO 6	3832	1940	3950	27400	2.50
	Greengram	CO 7	3831	2205	3949	32100	2.57
		CO6	3834	2021	3952	24675	2.05
	Blackgram	VBN 4	3830	1330	3948	13880	1.74
			3831	1367	3949	15480	1.86

Fig. 127a : Wheel hoe in operation for interculture in rainfed crops

Fig. 127b : Farmers' practice (interculture in rainfed crops)

1.8.3 PARBHANI

a. Agro-ecological setting

Parbhani centre is located in Central and Western Maharashtra plateau eco-sub-region. The climate is hot moist semi-arid. Annual normal rainfall is 901 mm.

b. On-station experiments

At Parbhani, the onset of monsoon was during third week of June i.e. delayed by 15 days compared to normal. A rainfall of 634 mm was received during cropping period of 2011 as against normal of 899.6 mm. An excess rainfall of was received July to an extent of 14.7 per cent when compared to normal rainfall. However, months like June, June, August, September and October received a deficit rainfall of 76.7, 20.4, 24 and 75.3 per cent, respectively. Further, no rainfall was received during November and December (Fig. 128).

Real time contingency crop planning

During *kharif* 2011, the onset of monsoon was delayed (3rd week of June) and there was deficit rainfall during crop growing season i.e. In June, August, September, October, November and December with overall deficit of 29.5 percent. The genotypes/ varieties/ hybrids of maize, groundnut, sunflower, safflower, cotton, sorghum, soybean and pigeonpea were evaluated for drought tolerance. The results are as under (Table 182 - 190).

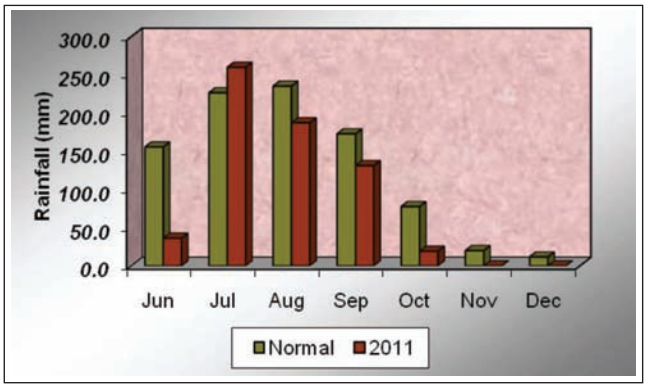

Fig. 128 : Normal and actual (2011) monthly rainfall at Parbhani

Performance of improved varities / hybrides / lines under delayed onset of monsoon and mid season drought

a) Maize

Sixteen genotypes of maize were evaluated during *kharif* 2011, genotypes pinnacle (Monsanto) was exhibited higher yield (6600 kg/ha) followed by DKC- 9117 (6200 kg/ha), 900- M Gold (6020 kg/ha), XC- 7246 (6210 kg/ha) and XC 7255 (6000 kg/ha) (Table 182).

Table 182 : Performance of maize genotypes

Variety/genotypes	Yield (kg/ha)
Kuber	5950
900 M-Gold	6020
XC-7246	6010
NMH-731	5800
XC -7255	6000
Pinnacle (Monsanto)	6600
NMH-220	5600
Rajashri	5200
DKC-9117	6200
Sangam (Mahabeej)	5400
NMH- 713	5800
NMH- 1242	5400
XC-8002	5600
NMH- 909	5800
NMH- 777	5600
NHM -666	5800

b) Greengram

Out of three genotypes of greengram evaluated TLG-45 gave higher yield (Table 183).

Table 183 : Performance of greengram genotypes

Variety/Hybrid	Yield (kg/ha)
LGN-1	1460
LGN-2	1230
TLG-45	1400

c) Sunflower

Sunflower hybrid KBSH-44 gave higher yield (1950 kg/ha) (Table 184).

Table 184 : Performance of sunflower genotypes

Variety/Hybrid	Yield (kg/ha)
LSH-35	1820
KBSH-44	1950
LSF-8	1250

d) Safflower

Safflower cv. PBN-12 performed better than PBB-40 (Table 185).

Table 185 : Performance of safflower genotypes

Variety/Hybrid	Yield (kg/ha)
PBNS-12	512
PBNS-40	141

e) Cotton

In cotton, MAU genotypes and *Bt* hybrid were tested in *kharif* 2011-2012 the genotypes Mallika *Bt* was revealed higher yield followed by Rashi-2 *Bt,* Ajit-155 *Bt* , Kanak Bt. and Pancham *Bt* and MAU genotypes NH- 630 exhibited higher yield than other (Table 186).

Table 186 : Performance of Bt cotton hybrids

Bt Hybrid	Yield (kg/ha)
Kanak *Bt* BG II	802
Attal *Bt*	704
Pancham *Bt*	814
Ankur *Bt* 651	802
MRC- 7326 *Bt*	802
Ajit -155 *Bt*	850
Bunny *Bt* (NCS-207)	643
Mallika *Bt*	930
Rashi-2 *Bt*	905
MRC-7347 *Bt*	793
Varieties	**Yield (kg/ha)**
NH-615	756
NH-545	818
NH-630	868
PH-348	843
PA-255	744

f) Sorghum

In sorghum, CSH-25 was performed higher grain yield (402 kg/ha) than other genotypes (Table 187).

Table 187 : Performance of sorghum varities

Variety	Yield (kg/ha)
PVK-801	3425
PVK-809	3265
Hybrid	
CSH-25	4020
CSH-16	3640
SPH-1641 (Parbhani sainath)	3520
SPH-400	3040

g) Soybean

In soybean, the MAUS -81 and MAUS-162 was performed higher seed yield (15.00 q/ha) than other genotypes (Table 188).

Table 188 : Performance of improved soybean varities

Variety/genotypes	Yield (kg/ha)
MAUS- 158	1250
MAUS- 47	1000
JS -135	1125
MAUS -71	1250
MAUS- 81	1500
MAUS- 61	1200
MAUS- 61-2	1250
MAUS -162	1500

h) Pigeonpea

Among six genotypes of pigeonpea was evaluated during *kharif* 2011, genotypes BSMR-736 was exhibited higher yield (4.80 q/ha) followed by ICPH- 2740 (4.00 q/ha), BSMR-853 and ICPH-671 (3.60 q/ha), BDN-711 (3.20 q/ha) and BDN-708 (3.00 q/ha) (Table 189).

Table 189 : Performance of pigeonpea varities/hybrides

Variety	Yield (kg/ha)
BDN-711	320
BDN-708	300
BSMR-853	360
BSMR-736	480
Hybrid	
ICPH-671	360
ICPH-2740	400

Soybean + pigeon pea (4:2) intercropping was revealed soybean seed yield (1215 kg/ha) and pigeonpea seed (1015 kg/ha). Pearlmillet + pigeon pea (4:2) intercropping was revealed pearlmillet yield (1210 kg/ha) and pigeon pea seed yield (1060 kg/ha) (Table 190).

Table 190 : Performance of improved intercropping systems

Intercropping system	Variety	Yield (kg/ha)
Soybean + pigeonpea (4:2) intercropping	Soybean (MAUS -71)	1215
	Pigeon pea (BSMR -853)	1015
Pearlmillet + pigeon pea (4:2) intercropping	Pearl millet (ABPC -4-3)	1210
	Pigeon pea (BSMR-853)	1060

c. On-farm experiments

Village profile

The program is implemented by AICRPDA Centre, Parbhani, in Pangri village in Jintur Taluka, Parbhani district, Maharastra state. The total cultivated area is 951.06 ha out of which 880.00 ha is rainfed. The mean annual rainfall is 835.00 mm with seasonal rainfall of 637 mm during *kharif* 2011 *(*June-September). The major soil types are medium deep to deep black soils. The major rainfed crops during *kharif* are soybean, sorghum, cotton, pigeonpea, greengram, blackgram and during *rabi* are sorghum, safflower and linseed. The number of small and medium, marginal and large farmers are 374, 75 and 25, respectively. The ground water table is 50 m below surface. The source of irrigation is well covering 5 per cent of cultivated area.

Climate Variability in General

The climate in this agro-climatic zone is semi-arid. Out of the total annual average rainfall of 835 mm, the south-west monsoon contributes 80 to 85%, north-east monsoon 10 to 15 % and summer rainfall about 5 %. The historical rainfall data (of 30 years) indicated that the variability in rainfall during south-west monsoon is 10 - 15 % deficit of the average rainfall. The onset (south-west) of monsoon is during 22 - 23 SMW. For the past 15 years, the dry spells during crop season were experienced during August and at vegetative or reproductive stages of the major rainfed crops. The onset of the monsoon was normal. The soil moisture status was deficit during maturity stages of major rainfed crops. The maximum and minimum temperature during crop season are 41^{0}C and 21^{0}C respectively. The extreme events like unusual and high intensity rainfall in short span were increasing during *kharif* and *rabi* seasons. There had been considerable shift in rainfall pattern and it is observed that during last 5 years onset of effective monsoon was received in the 1st fortnight of July instead of last week of June. Hence, normal sowing period during *kharif* was delayed i.e. 1st fortnight of July.

Experienced weather conditions during the year (2011-12)

The village received 637 mm which was deficit of 198 mm compared to normal 835 mm during south-west monsoon (*kharif*) (Fig. 129). The crops experienced dry spells in the month of August during vegetative and reproductive stages of various crops.

Interventions

The major interventions were implemented under on-farm include land configuration, crops or varieties/ cropping system, rainwater harvesting and recycling, timely operations through custom hiring center and alternate land use and ecosystem services. These interventions covered an area of 150 acre in 177 farmers' fields.

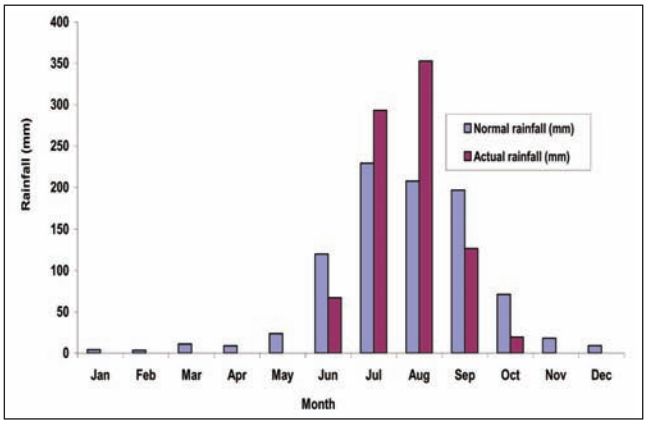

Fig. 129 : Normal and actual (2011) monthly rainfall at Pangri Village

Land configuration

The land configuration included ridge furrow system in soybean + pigeonpea intercropping system (Fig. 130a) which facilitated runoff modulation, improved the drainage in black soils and enhanced *in-situ* moisture conservation. This resulted in mitigating dry spell during vegetative and flowering stage of soybean and enhanced the crop yield by 26.62% and RWUE by 2.98% compared to flat bed sowing (Fig. 130b). Further, ridge and furrow system in soybean + pigeonpea intercropping (4:2) enhanced both main and intercrop yields and RWUE up to 26 compared to farmers practice of flat bed system in the same intercropping system.

There was a deficit rainfall of 29%. To mitigate the dry spell, the farmers were advised to adopt in situ moisture conservation practices viz. conservation furrow and broad bed furrow 30 days after sowing in sole soybean (Fig. 130c). The rainwater particularly in the month of August was conserved and utilized efficiently which otherwise experienced moisture stress (Fig. 130d). The farmer, Mr. Tukaram Palwe could realized highest soybean yield of 2250 kg/ha with opening of furrow after every 4 rows at 30 DAS. Another farmer, Mr. Ramrao Budhwant obtained

soybean yield of 2150 kg/ha by adopting conservation furrow at a distance of 10 m interval. Other farmers (Mr. Fakira wagh, Mr. Dyneshwar Budhwant and Mr. Ramkisan Budhwant) could obtain soybean yield of 2000 kg/ha by adopting conservation furrow (Table 191a). The farmers viz. Mr. Shankar Budhwant, Mr. Kashinath Budhwant, Mr. Deepak Ghuge and Mr. Bhagwan Budwant who did not practice any in situ moisture conservation practices in soybean could realize in soybean yield of 1750 to 1825 kg/ha only. There was increase in yield of soybean up to 28.5 per cent (Table 191b) with adoption of opening of furrow and conservation furrow as in situ rain water conservation techniques.

Fig. 130a : Ridge and furrow system in Soybean + pigeonpea intercropping (4:2)

Fig. 130b : Flat bed sowing in Soybean+ pigeonpea intercropping (4:2)

Table 191a : Performance of soybean and soybean + pigeonpea intercropping with ridge and furrow system under normal on set of monsoon and mid season drought

Crop	Variety	Yield (kg/ha)		% increase in yield	RWUE (kg/ha-mm)	BC ratio
		Improved practice	Farmers' practice			
Soybean	MAUS-71	1950	1540	26.62	2.98	1.59
Soybean + pigeonpea intercropping (4:2)	MAUS-71 + BSMR 853	1500 + 850	1250 + 720	20.00 18.05	3.68	2.34

Fig. 130c : Opening of conservation furrow 30 DAS in Soybean

Fig. 130d : Good soybean crop with better *in situ* moisture conservation

Table 191b : Impact of *in situ* moisture conservation practices on soybean yield

Name of Farmer	Variety	Date of sowing	Date of harvesting	Yield (kg/ha)	Practice adopted
Tukaram B Palve	MAUS-71	05/07/11	12/10/11	22.50	Opening of Furrow
Fakira M Wagh	MAUS-71	10/07/11	15/10/11	20.00	Conservation furrow
Ramrao S Budhawant	MAUS-71	10/07/11	15/10/11	21.25	Conservation furrow
Ramkisan B Budhawant	MAUS-81	05/07/11	17/10/11	20.00	Conservation furrow
Dnyaneshwar Budhawant	MAUS-71	10/07/11	15/10/11	20.00	Conservation furrow
Shankar A Budhawant	MAUS-71	09/07/11	15/10/11	18.75	No Treatment
Dipak P Ghuge	MAUS-71	08/07/11	13/10/11	17.50	No Treatment
Bhagwan Budhawant	MAUS-81	09/07/11	16/10/11	17.50	No Treatment
Kashinath Budhawant	MAUS-158	05/07/11	15/10/11	18.75	No Treatment
Devrao Budhawant	MAUS-158	09/07/11	18/10/11	17.50	No Treatment
Ramkisan S Budhawant	MAUS-81	05/7/11	18/10/11	18.75	No Treatment

Crops/ Varieties/Cropping system

The drought tolerant soybean (MAUS 71,MAUS 81)), greengram (BM 2001-1), blackgram (BDU-1), pigeonpea (Fig. 131) (BSMR 736, BDN 708,BSMR 853) and peralmillet (ABPC-1) during *kharif 2011* were introduced to cope with the delayed on set of monsoon. The improved varieties performed better even sown late and moisture stress during vegetative (for all crops) and reproductive stages (varieties of greengram, blackgram) and the yield increase was up to 28.57 % with BC ratio up to 2.12 (Table 192).

Fig. 131 : Performance of pigeonpea - BSMR 736

Rainwater harvesting and recycling

The existing farm pond is of size 30 x 30 x 3 m was renovated. As the rainfall was deficit, no rainfall was recorded hence rainwater were not harvested in farm pond.

Timely operations through Custom Hiring Center

A custom hiring center was established in the village with need based implements and a Custom Hiring Committee was constituted to facilitate activities smoothly. The procurement of equipment was delayed hence, implements could not be provided.

Table 192 : Performance of improved varities of rainfed kharif crops under normal onset of monsoon and mid season drought condition

Crop	Variety	Yield (kg/ha)		% Increase In yield	BC ratio
		Improved practice	Farmers' practice		
Soybean	MAUS 71	1800	1500	20.00	1.83
	MAUS 81	1750	1500	16.66	1.91
Pigeonpea	BSMR 736	1350	1050	28.57	2.01
	BDN 708	1400	1100	27.27	2.12
	BSMR 853	1300	1050	23.80	1.90
Greengram	BM 2002-1	750	650	15.38	1.52
Blackgram	BDU-1	840	720	16.66	1.27
Pearlmillet	ABPC-1	1250	1100	13.63	1.51

2 NICRA - Strategic Research

Adaptation Strategies through Cropping Systems at Selected Soil Benchmark Sites

Risk coping production systems resilient to climate, land and water modifications require diversified structures in space and time such as cropping systems. Inter-annual and intra annual seasonal climate variability is one of the major factors influencing biophysical systems, further the spatial variability of soils in turn affect the ability of the crops/cropping systems to cope up with dry spells/drought and finally yields. The present study was undertaken with the twin aassessing climate risks at selected sites and identifying risk coping cropping systems at selected soil benchmark sites (on-farm research). During 2011-12, the study on assessing microlevel climate risks was undertaken at three microwatersheds viz., Kavalagi ,Bijapur district, Karnataka, Warkhed in Akola district, Maharashtra and Sola ka Kheda in Bhilwara district, Rajasthan. Conducted PRA, personal interviews (50 farmers in Varkhed, 60 farmers in Kauai and 50 farmers in Sola ka Knead watersheds) with structured proformae (household, village and for stress assessment) and focused group discussions (Fig. 132a, 132b & 132c).

The results are presented below:

i) At Warkhed watershed : 80 % farmers are small with agriculture as main livelihood while only 4 per cent have livestock based income.. Majority of the farmers (92%) opined that deforestation, increasing pollution were the reasons for climate variability and manifested in delayed onset of SW monsoon, early withdrawal of monsoon, decrease in total amount of rainfall, hot summers, more intense rains, less rainy days, increase in frequency of midseason droughts. Majority indicated that e - traditional forecasts are no more valid. For the last 10 years, dominant kharif crops viz. soybean, cotton and pigeonpea are late sown, experience midseason drought, while rabi crops chickpea and wheat are affected by unseasonal rainfall. 92 % of the farmers opined that fodder scarcity (now from February to May earlier April and May), mechanization and capital constraints were the reasons for low livestock holding.

Traditional coping mechanisms as adaptation strategies at Warkhed watershed are: Soybean is the new introduction (last 10 years) because of less risk, stability, higher yield and income. There had been increase in mixed/intercropping i.e. cotton + greengram, cotton + pigeonpea. Dry sowing of cotton (early sowing) is decreasing while late sowing of *kharif* rainfed crops was increasing. Traditional crop management practices as adptation strategies at various stages of crops and under low and excess rainfall situation is given below.

a) at early crop stage –

- Less than normal rainfall situation : resowing of soybean, cotton
- Excess rainfall : gap filling and draining excess water in sorghum, soybean and cotton, stone plugging (Fig. 133a, 133b)

b) at vegetative stage and flowering stage

- Less than normal rainfall situation: supplemental irrigation (borewell/open dug well) in soybean and supplemental irrigation, interculture in cotton
- Excess rainfall situation : insecticide spray in cotton, interculture in soybean

c) at harvest stage

- Terminal drought situation– advance harvest in soybean and delay harvest in cotton.
- Excess rainfall situation - delay harvest in soybean and cotton

Fig. 132a : Solaka Kheda watershed

Fig. 132b : Warkhed watershed

Fig. 132c : Kavalagi watershed

Fig. 132 (a to c) : PRAs and FGDs at three microwatersheds

Fig. 133a : Stone plugging or excess rainfall events

Fig. 133b : Improved drainage in sorghum during excess rainfall

Fig. 133 (a & b) : Coping strategies during excess rainfall events

In the last 15 years, 13 % farmers made investments on irrigation resources like bore wells, open dug wells, 2.5 % on digging farm ponds and 5 % on horticulture and livestock and purchasing crop insurance. The bbarriers to adaptation to climate variability are, the foremost is lack of information followed by lack of credit/capital, non - remunerative prices, increasing labour scarcity, insecure property rights, lack of infrastructure like storage, processing, transport etc and lack of institutional support.

ii) At Kavalagi watershed: 82 % farmers are small with agriculture as main livelihood while only 12 per cent have livestock based income. Majority of the farmers indicated reasons for climate variability are deforestation, increasing pollution, increasing urbanization,/ industrialization and climate variability manifested in delayed onset of SW monsoon, midseason droughts during rabi season, more intense rains both during kharif and rabi, less rainy days during kharif, increase in frequency of midseason droughts and the impact on cropping pattern is that the kharif crops are more affected than rabi crops, led to early sowing of rabi sorghum, late sowing of chickpea, and sunflower, midseason drought in rabi sorghum and unseasonal rainfall affecting chickpea. Further, low and inadequate rainfall led to labour and fodder scarcity during November and December, hence low livestock holding.

Traditional coping mechanisms as adaptation strategies identified at Kavalagi watershed are : During *kharif* , the cropping pattern shifted to onion due to late sowings during kharif, Bt cotton, cotton +chilies, onion + chillies. Farmers maintain seed stock for the next season and also for contingency planning. Traditional crop management practices as adptation strategies at various stages of crops and under low and excess rainfall situation is given below.

a) before sowing

- Less than normal rainfall situation : during *rabi* fodder crops instead of chickpea and sorghum, change in variety in sorghum, chickpea, pigeonpea and wheat
- Excess rainfall : change in crop instead of chickpea, sorghum
- Management Practices

b) at early crop stage

- Less than normal rainfall situation: conservation furrow in chickpea, resowing and gap filling in pigeonpea,
- Excess rainfall:draining out excess water in chickpea, sorghum, resowing of sunflower

c) at vegetative stage

- Less than normal rainfall situation : urea (about 1 %) spray in chickpea, additional N application in sorghum
- Excess rainfall : additional N application and salt spray in sorghum and pigeonpea

d) at flowering and grain filling stages

- Less than normal rainfall situation : additional N application in sorghum,pigeonpea and wheat
- Excess rainfall : additional N application and salt spray in sorghum and pigeonpea

e) at harvest stage

- Terminal drought situation : delay harvest of chickpea and pigeonpea and insecticide spray in chickpea and sorghum ,delay harvest of
- Excess rainfall situation: delay harvest and insecticide spray in chickpea and sorghum, advance harvest of pigeonpea.

iii) At Sola ka Kheda watershed: 98 % farmers are small with agriculture , 50 % agriculture as main livelihood while 25% livestock based income and 24 %- engage in off-farm activities. Majority of the farmers (92%) strongly opined that the reasons for climate variability are deforestation, increasing pollution , increasing population, increasing urbanization. Majority opined that in the last

15 years (since 2004-05) there had been shift in the onset of monsoon, frequency of drought in village had been twice in 5 years, decline in groundwater table, only *kharif* cropping with prevalence of midseason and terminal droughts, During last 15 years the sowing window of maize shifted from last week of June or first week of July to 7 th to 20 th July. Due to erratic rainfall in last 10 years, there had been reduction in maize yield by 50 to 100%. Fodder scarcity, capital constraints are the reasons for low livestock holding.

Traditional coping mechanisms as adaptation strategies at Sol ka Kheda watershed are: Due to change in sowing time and high frequency of mid-season and terminal droughts, preference of farmers changed from traditional long duration maize varieties to Sathi local and short duration high yielding composites and hybrids. Practice of deep tillage increased before monsoonal rain and soil mulching after *kharif* rains. During low rainfall years, small farmers had been emphasizing in practicing of mixed cropping of blackgram, greengram, cowpea, kachari, vegetables in maize and sesame in groundnut. Earlier farmers used to put higher seed rate of maize (35-40 kg/ha) and lower in groundnut (60-80 kg/ha), however, now prefer low seed rate of maize (25-30 kg ha^{-1}) and higher for groundnut (80-100 kg/ha). Mid-season corrections like staggered uprooting of weeds in crops over the period of three weeks and detasseling of maize had been increasing during long dry spells. Deepening of *Nadi* (local water harvesting structure) and number of water harvesting and storage structures increased at a faster rate in the last 10 years. Farmers maintain seed stock for the next season and also for contingency planning. Traditional crop management practices as adptation strategies at various stages of crops and under low and excess rainfall situation is given below.

a) before sowing

- Less than normal rainfall situation: in case of cotton and sesame – change the crop; groundnut and maize – change in variety
- Excess rainfall situation : cotton – change in crop; groundnut, maize,sesame; wheat – change in crop and or variety

b) at early crop stage

- Less than normal rainfall situation: cotton – thinning; groundnut and maize – conservation furrow, thinning and gap filling
- Excess rainfall situation : cotton – gap filling; groundnut and maize - thinning, gap filling, draining out excess water; sesame – gap filling, draining out excess water

b) at vegetative stage

- Less than normal rainfall situation: groundnut and maize – salt water spray, intercultivation, supplemental irrigation
- Excess rainfall situation : additional fertilizer application and salt spray in groundnut, sesame and maize

c) at flowering and grain filling stages

- Less than normal rainfall situation: as in case of vegetative stage
- Excess rainfall situation: maize, groundnut; sesame – application of fertilizer

d) at practices at harvest stage

- Terminal drought: delay harvest of cotton, groundnut, maize, sesame
- Excess rainfall: delay harvest of cotton, groundnut, maize, sesame

The predominant soil types in Kavalagi watershed are shallow to deep very fine, calcareous black soils (Calcic/ Typic Haplusterts, Vertic Ustropepts, Typic/Lithic Ustorthents, Typic Ustifluvents) (Fig.1), in Warkhed watershed are shallow to very deep, clayey loam to clayey black soils (Typic Ustorthents, Vertic Ustrochrepts,Typic Haplusterts) and in Sola ka Kheda are deep to very deep fine loamy black soils (Typic Ustorthents, Typic Haplustepts).

There was marked change in soil properties in 2011 compared to 2001, particularly in respect of pH, organic carbon and available N, P and K across Entisols, Inceptisols and Vertisols in Warkhed watershed. The soil microbial carbon (SMBC) (ug/g) and dehydrogenase activity (DHA) was analysed for various crops across soil types in Warkhed and Kaulagi watersheds. At Warkhed watershed, across fallow lands, sorghum, soybean and cottons and across shallow entisols, deep inceptisols and very deep vertisols the SMBC ranged from 85.6 ug/g to 330.7 ug/g and DHA values ranged from 1.7 mic.g/g/hr to 8.4 mic.g/g/hr while at Kaulagi watershed, across sorghum and chickpea and across shallow entisols to very deep, calcareous vertisols, the SMBC ranged from 96.8 u/g to 331.2 ug/g and DHA values ranged from 1.5 mic.g/g/hr to 4.5 mic.g/g/hr. Over a period of one decade (2001 to 2011), there are no significant changes in chemical properties in the ground water quality in Kaulagi watershed.

3 NICRA - Other Activities

3.1. Launching Workshops in Adopted Villages

The NICRPA programme across AICRPDA network centres initiated during 2010-11. Guidelines were prepared by PC Unit, AICRPDA, for slection of villages and the process of programme implementation. The programme was launched in adopted villages as detailed below (Table 193).

Table 193 : Launching Workshops in NICRA villages

Production System / Centre	Launching workshop date
Rice Based Production System	
Biswanath Chariali	12/4/2011
Chianki	1/8/2011
Faizabad	*
Jagadalpur	15/3/2011
Phulbani	*
Varanasi	19/4/2011
Maize Based Production System	
Arjia	1/3/2011
Ballowal Saunkhri	19/4/2011 & 23/5/2011
Rakh Dhiansar	*
Fingermillet Based Production System	
Bangalore	7/9/2011
Pearlmillet Based Production system	
Agra	17/7/2011
Hisar	16,17,18/5/2011
S.K.Nagar	12,19/10/2011
Sorghum Based Production System	
Bijapur	29/9/2011
Solapur	1/7/2011
Jhansi	6/3/2011
Soybean Based Production System	
Indore	21/4/2011
Rewa	26/9/2011
Groundnut Based Production System	
Anantapur	20/9/2011
Rajkot	30/5/2011
Cotton Based Production System	
Akola	13,14/5/2011
Kovilpatti	8/11/2011
Parbhani	28/6/2011

3.2. PRA Activities

The PRA, FGDs focused on climate characterization of the village, participatory village with regard to farming systems, resource situation, constraints and climate vulnerabilities to identify the opportunities of climate change adaptation and mitigation,the other details of land use and agricultural scenario and allied sectors, awareness of farmers about climate change, water resources etc. Assessment of natural resource status with regard to agriculture vis-à-vis private vulnerability that assessed the status of natural resource, socio economic institutional and infrastructural status and major farming systems. The resource inventory focused on soil quality status, (Fig. 134 to 140) land suitability to crops, surface and ground water resource, bio-diversity, etc.,socio economic status information at household level, and the institutional arrangement at village level, like input access arrangements, Govt. schemes, committee groups, SSGs, etc.Constraint analysis was done related to climate variability based on secondary weather data, resource situation, farming systems and agricultural yields, particularly that focus on water scarcity, droughts, seasonal and unseasonal droughts, extreme events, external disease scenario, water scarcity, farm mechanization, etc. The centers based on the above exercise, each center developed technical program based on the technological intervention available at the centers or from the respective regional/ zonal research stations of SAUs and ICAR Institutions and also the time tested climate resilient farming practices started by innovative farmers. Thus, the identified specific interventions related to each of the four sub-projects of the program. It was planned to saturate the whole village with the identified interventions in order to demonstrate a discernable effect and document constraints and lessons. Further the preference was given to the interventions targeted/focused on the following:

- Interventions benefiting larger and resource poor group
- Interventions which give long-term and sustainable benefits
- Interventions that address resource conservation
- Interventions that promote/strengthen village level institutions

Fig. 134a : Resource map of NICRA village (land type, land use pattern, farm ponds and others)

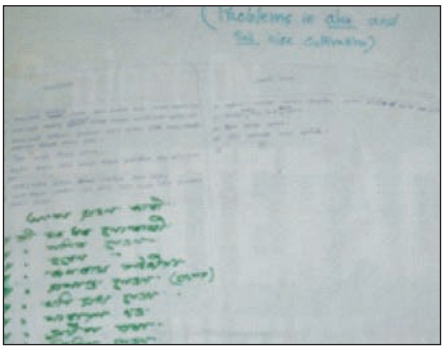

Fig. 134b : Problems of Ahu and Sali rice cultivatios in NICRA village

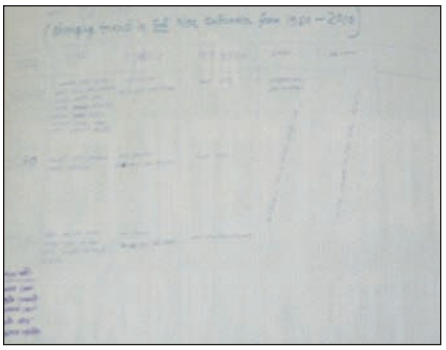

Fig. 134c : Changing trend in Sali rice cultivation from 1960 to 2010

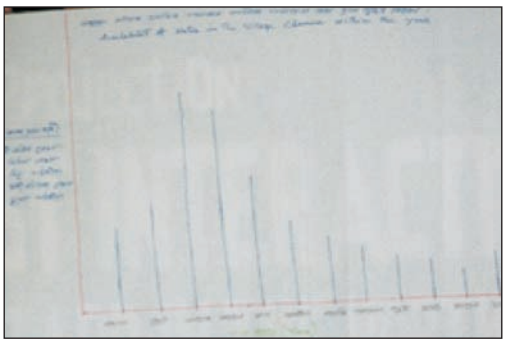

Fig. 134d : Seasonality analysis on availability of water in the NICRA village Chamua within the year

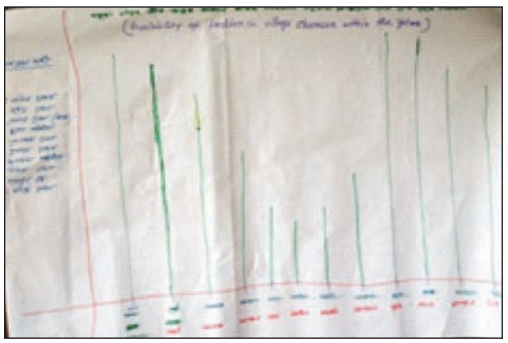

Fig. 134e : Seasonality analysis on availability of fodder at NICRA village within a year

Fig. 134 (a to e) : PRA Maps of Chamua village (Biswanath Chariali centre)

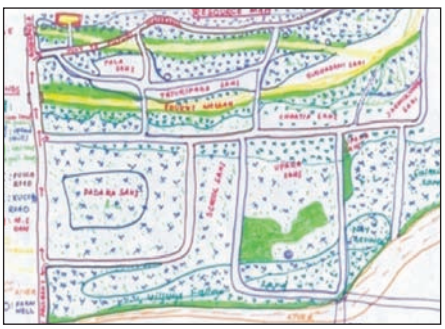

Fig. 135b : Village resource map (land use pattern)

Fig. 135b : Village Social Mapping

Fig. 135c : PRA in Progress

Fig. 135 (a to d) : PRA Activities and Maps in Budhadhani village (Phulbani centre)

Fig. 136 : PRA Maps of Khumbhi - Bankheta village (Chianki centre)

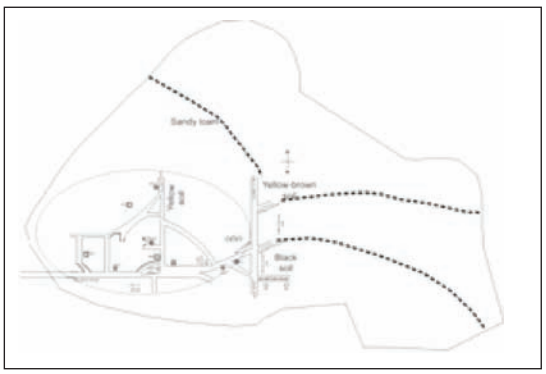

Fig. 137a : Transacts walk across the Kochriya watershed

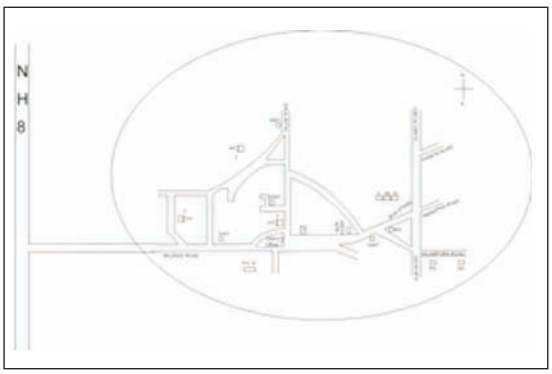

Fig. 137b : Social & resource map of village Kochariya

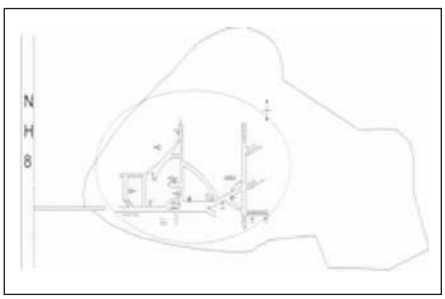

Fig. 137c : Agroecological map of village Kochariya

Fig. 137d : Agroecological mapping by the villagers of Kochariya

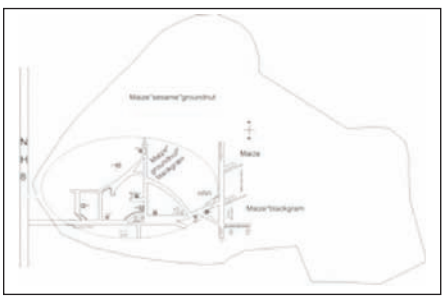

Fig. 137e : Crop technology map of village Kochariya

Fig. 137 (a to e) : PRA Maps of the Kochariya village (Arjia centre)

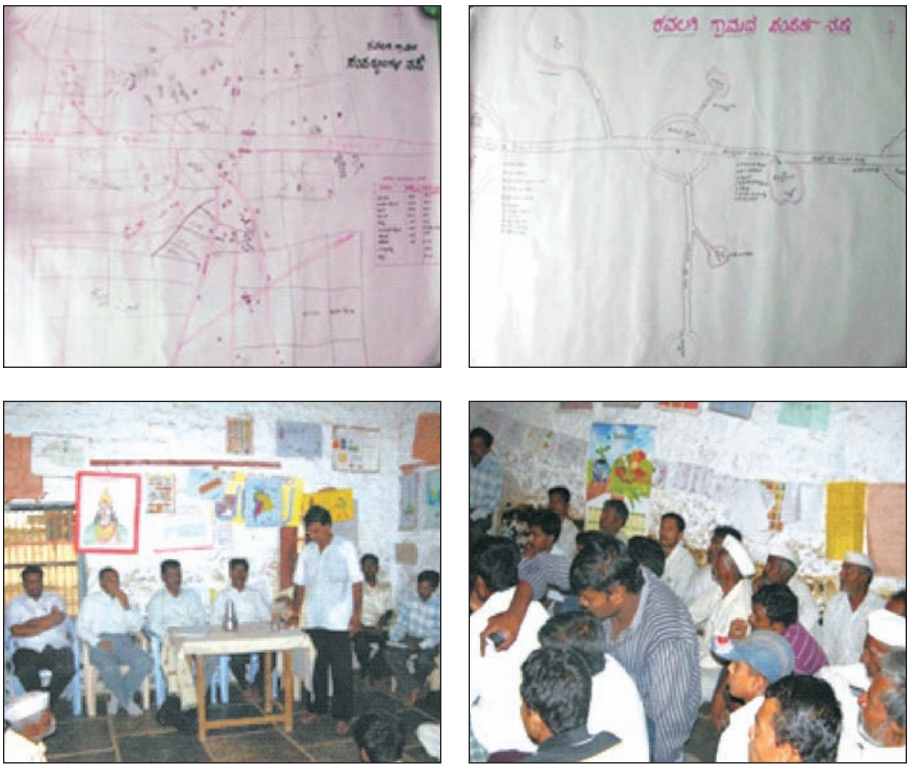

Fig. 138 : Maps and activities in Kavalagi village (Bijapur centre)

Fig. 139a : Cadastral map

Fig. 139b : Village map

Fig. 139e : Cropping- pattern map, Jhansi

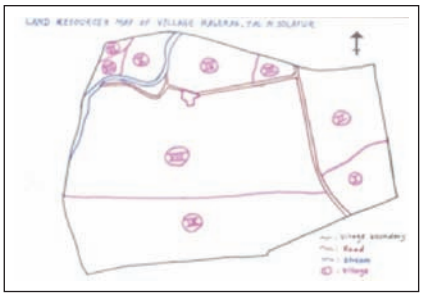

Fig. 139c : Land Resources Map of village Raleras

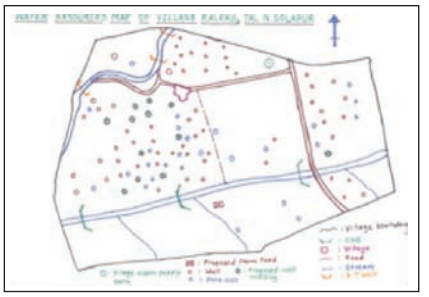

Fig. 139d : Water Resources Map of village Raleras

Fig. 139f : Water- Resource map, Jhansi

Fig. 139 (a to f) : PRA activities in Raleras village, (Solapur centre & Kadesara Kala village, Jhansi)

Fig. 140a : Social and Resource Mapping

Fig. 140b : Seasonality analysis

Fig. 140c : Resource mapping at Warkhed (Bk), (Akola centre)

Fig. 140 : PRA activities in NICRA Villages (Anantapur, Akola Centres)

3.3 Custom hiring centres

Each village has one Custom Hiting Centre (CHC), Climate Risk Resilient Management Committee (CRRMC) and Custom Hiring Management Committee (CHMC)huge demand for these equipments in the Custom hiring centre. The need based implements based on the decisions at village level and approved by VCRMC , are made available for facilitating the hiring of implements as per the rates by CHMC. The money incurred from the custom hiring is maintained for manitenanace and repair of the implements.

For eg. The activities of CHC in Chikkamaranhalli village adopted by Bangalore centre is presented below (Fig. 141, 142).

Custom hiring centre management committee is formed by involving 9 farmers and scientists. In a meeting held with farmers and scientists, the equipments required for the Custom hiring centre was decided and purchased. The guidelines for managing the Custom hiring centre was finalized in the Custom hiring centre management committee meeting held on 5th July, 2011 at Milk dairy, Chikkaputtaiahanapalya. Two registers, namely one for indent and another for receipts have been maintained. In order to keep the equipments one shelter has been errected. One hundred and nine farmers have been benefited from Custom hiring centre. The details of custome hiring center committee members are given below.

Fig. 141 : Custom hiring centre committee meeting held 5-7-2011 at Chikkaputtayanapalya, Bangalore

Fig. 142 : Implements in the custom hiring centre at Bangalore

Committee for custom hiring center

SNo.	Farmers list	Village names
1.	Gopalaiah	Chikkaputtayanapalya
2.	Hanumantharayappa	Chikkaputtayanapalya
3.	Ramakrishnaiah	Chikkaputtayanapalya
4.	Gubbanna	Chikkamaranahalli
5.	Venkatappa	Chikkamaranahalli
6.	Ravikumar	Mudlupalya
7.	Manjunatha (Gubbanna's brather)	Chikkamaranahalli
8.	Nagraju	Chikkaputtayanapalya
9.	Prasanna kumar	Chikkaputtayanapalya

Farmers are using the equipments from the custom hiring centre. Seed drill is widely used in the finger millet sowing followed by disc plough, spike tooth harrow, sprayers, cultivators and hand weeders. As on 24th May 2012 total hire charges of Rs.4277/- has been already collected and kept in the joint account (A/C.No.9290) in the names of Gopalaiah, Gubbanna and Prasannakumar in PDCC bank, Nelamangala. Farmers are showing good response and mutual co-operation in using these equipments. In days to come it is expected.

The various activities of Custome Hiring Centres are shown in Fig. 143 to 146.

Fig. 143 : Custome hiring centre and usage of farm implements at Arjia

Fig. 144 : Custome hiring centre at Bijapur

Fig. 145 : Custom hiring centre, Phulbani

Fig. 146 : Hired implement in operation

3.4. Review Workshops, Traininging/ Meetings/Field days Organized

3.4.1. NICRA Review Meeting

A Review Meeting of NICRA programme at AICRPDA centres was held on 8th April 2001, New Delhi. Dr.S.Ayyappan, Secretary, DARE and DG, ICAR, Dr.A. K. Singh, former DDG (NRM),Dr.P.S. Minhas, former ADG (Soils) reviewed the progress (Fig. 147). Scientists - farmers interaction meetings were also held in NICRA villages for senstization at climate variability and other activities (Fig. 148a & 148b) (Table 194).

Fig. 148a : Scientists-farmers' Interaction Meeting, Pata Meghpar village, Rajkot centre

Fig. 147 : DG, ICAR, releasing Technical Bulletin on Climate Resilient Agriculture

Fig. 148b : Scientists-farmers' Interaction Meeting, Raleras, Solapur centre

Table 194 : Meetings organized by AICRPDA centres

Center	Activities	No of Benefi-ciaries	Date & Venue
Jhansi	Farmers Meeting	30	Kadesara kalan
Anantapur	Climatic change meeting	30	02-02-2012
	Village Risk management and NICRA custom hiring committee	52	07-02-2012
Rajkot	Rabi crop contingency planning	60	18-10-2011- Pata Meghpar
	World Soil Day	104	05-2012-2011- Pata Meghpar
	Krushi Week (12-17,Sept) for farmers at KVK, Targhadia	14	05-09-2011 AICRPDA, Rajkot
	Stalk Holders Meeting	20	30-09-2011 AICRPDA, Rajkot

3.4.2.Trainings Organized

a) Project Coordination Unit, AICRPDA, Hyderabad, PC Unit

Two Short Courses on "Database Analysis and Management in Climate Variability and Rainfed Agriculture" under National Initiative on Climate Resilient Agriculture (NICRA) were organized by Project Coordination Unit, AICPRDA during 21- 25 February, 2012 and 27th February to 2nd March, 2012 at CRIDA. The program was conducted as a capacity building measure under NICRA (Fig. 149 & 150).

The topics covered are

i) Concepts of database management

ii) Working experience of Weathercock software to analyse climate data

iii) Concepts of Remote sensing and GIS for spatial database design

iv) Updation and maintenance of the designed web pages of a centre using Joomla software

v) Statistical procedures for analysis of data of rainfed experiments

vi) Minimum data sets for cropping systems

vii) Analysis of Input and Output energy data in rainfed agriculture

viii) Rainwater management – data analysis

ix) Economic analysis of resource conservation technologies and

x) Updating of Agricultural Field Experimental Information systems (AFEIS). The pedogoy include the theory and practical (hands on experience) on various topics.

Participants include the scientists, technical officers/ assistant and RA/SRF (under NICRA) from the network centres of AICRPDA viz 25 participants in the first short course (15 scientists, 2 technical and 8 RA/SRFs) from 11 centres and 28 participants in the second short course (10 scientists, 6 technical and 12 RA/SRFs) from 12 centres. The course is useful in climate / weather analysis for various interventions to be adopted in NICRA villages and also database management.

Er. R.Nagarjuna Kumar, Scientist (Computer Applications) was the Course Coordinator for first short course and Dr.G.Ravindra Chary, Principal Scientist (Agronomy) was the Course Coordinator for second short course. Other coordinators are. Dr. G.R.Maruthi Sankar, I/c, PC(AICRPDA) & Mr. AV.M.Subba Rao, Scientist (S.S) (Agromet).

Fig. 149 : Participants of First Short Course

Fig. 150 : Participants of Second Short Course

b) Trainings organized by AICRPDA Centres

AICRPDA centres organized need based and skill oriented training programmes on various aspects of improved technologies to farmers, extension workers. The details of training programmes conducted are given in (Table 195).

Table 195 : Trainings organized by AICRPDA centres

Center & Topic	No of Beneficiaries	Date andVenue
Arjia		
Field visit cum training of farmers to live demonstration of biogas plants		01-06-2011- Chitamba and Phacolia village
Pre-seasonal training on kharif crops	95	07-06-2011- Lapsiya village, Rajsamand district (Rajasthan)
Biogas and water harvesting structures	31	07-01-2012- village Kochriya district Bhilwara (Rajasthan)
Biogas and water harvesting structures	63	24-01-2012- village Lapsiya district Rajsamand (Rajasthan)
Bangalore		
Dryland Technologies		4-5-2011- Chikkaputtayanapalya of Nelamangala taluk
SK Nagar		
Improved Dryland Technologies	30	Sardarkrushinagar Dantiwada Agricultural University
Bijapur		
Soil and water conservation (Compartment bunding, ridges and furrows etc.,) Training program		01-07-2011 - Kavalagi village
Crop contingency planning Training program		01-08-2011 - Kavalagi village
Jhansi		
Groundnut Field Day cum Farmers Training workshop	65	Kadesarakalan Village
Indore		
Kissan Diwas and Field visit was organized under NICRA village	55	7-2012-2011- Ningnoti, Indore
Anantapur		
Pest and nutrient management in castor	32	19-07-2011
Pest and nutrient management in cotton	32	19-07-2011
Farm pond training program at NICRA Village	32	19-07-2011
Improved production technologies in Millet and pulses	35	22-07-2011
Training program on tomato fruit protection measures.	44	06-09-2011
Pest and nutrient management in castor	62	06-09-2011
Pest, nutrient and fruit quality management in Tomato	50	07-09-2011
Post harvest technology on tomato	31	28-09-2011
Improved practices in Redgram	36	30-09-2011
Bajra cultivational practices	53	30-09-2011
Redgram plant protection measures.	44	22-10-2011
Improved Dryland technology	55	14-03-2012
Rajkot		
INM in *Kharif* Crops	75	05-08-2011- Pata Meghpar
IPM in *Kharif* Crops	92	13-09-2011- Pata Meghpar
Organic farming and recycling of crop residue	40	19-05-2011- AICRPDA, Rajkot
Kovilpatti		
Cultivation technologies for rainfed crops	30	27-07-2011
Improved rainfed technologies	25	20-03-2012

3.4.3 Field Days organized

Field days were organized on NICRA demonstration programmes for various stakeholders (Fig. 151a, 151b & 151c) (Table 196).

a) Arjia

- Field day on improved intercropping system of groundnut+ sesame (6:2) in Village Sola ka kheda district Bhilwara (Rajasthan) on 27-08-2011
- Field day on improved variety of groundnut and FLD on Horsegram in village Kochriya district Bhilwara (Rajasthan) on 14-09-2011
- Field day on improved variety of improved dryland technogies i.e. maize+ blackgram (2:2) and dual purpose variety of sorghum (CSV-15) in village Tara ka Kheda district Rajsamand (Rajasthan) on 16-09-2011
- Field Day on improved variety of improved dryland technogies i.e. groundnut + sesame (6:2) in village Lapsiya district Rajsamand (Rajasthan) on 22-09-2011
- Field day on improved pasture development at village
- Field day on seed bank of groundnut variety TG 37 A

Fig. 151a : Field Day, Kochariya Village, Arjia centre

Fig. 151b : Field Day in NICRA village, Ballowal Saunkhri

Fig. 151c : Field visit on FLD of INM in cotton, Psata Meghapur

Fig. 151 (a to c) : Field days in NICRA villages

Table 196 : Details of field days conducted at AICRPDA centres

Center	Activities	No of Benefi-ciaries	Date and Place
Arjia	Field Day on improved intercropping system of groundnut+ sesame (6:2)	98	27-08-2011- Village Sola ka kheda district Bhilwara (Rajasthan)
	Field Day on improved variety of groundnut and FLD on horsegram	63	14-09-2011- village Kochriya district Bhilwara (Rajasthan)
	Field Day on improved variety of improved dryland technologies i.e. maize+ blackgram (2:2) and dual purpose variety of sorghum (CSV-15)	78	16-09-2011- village Tara ka Kheda district Rajsamand (Rajasthan)
	Field Day on improved variety of improved dryland technogies i.e. groundnut+ sesame (6:2)	92	22-09-2011- village Lapsiya district Rajsamand (Rajasthan)
	Field Day on improved pasture development at village	55	15-10-2011- village Bagatpur district Rajsamand (Rajasthan)
	Field Day on seed bank of groundnut variety TG 37 A	40	15-2011-2011- village Kochriya district Bhilwara (Rajasthan)
Bangalore	National Krishi Mela	55	16-2011-2011 to 20-2011-2011 GKVK, UAS, Bangalore
Indore	*Kissan Diwas* and Field visit was organized under NICRA village	55	7-2012-2011- Ningnoti, Indore
Rajkot	Krushi Week (12-17,Sept) for farmers at KVK, Targhadia	14	05-09-2011 AICRPDA, Rajkot

3.5. Agro Advisories

Agro-advisories through ICTs (information kiosks) combining the village level weather data linked to district advisory issued by the IMD/SAU.

Under the project in collaboration with AICRPAM and IMD twice a week (Tuesdays and Fridays) agro-advisories and crop-weather bulletins were issued and messages were written in front of milk collection centers of Chikkaputtayyanapalya and Hosapalya and also broadcasted in the local Radio Neladhani for the benefit of project farmers and surrounding villagers (Fig. 152). Daily weather information and coping strategies were given in NICRA villages (Fig. 153).

Fig. 152 : Agro advisory information in the NICRA village, Bangalore

Fig. 153 : Weather information and Agroadvisory in Kochariya village, Arjia

3.6. Soil Health Cards and Community seed banks

The soil sampling and analysis of each land parcel in NICRA villages was done and developed Soil Health Cards for each farmer. An example of Soil Health Card issued to the farmers of Kavalagi village adopted by Bijapur centre (Fig. 154) is shown below. To meet the seed demand for normal and delayed onset of monsoon, a Community Seed Bank was developed in adopted villages of AICRPDA centre, Arjia (Fig. 155).

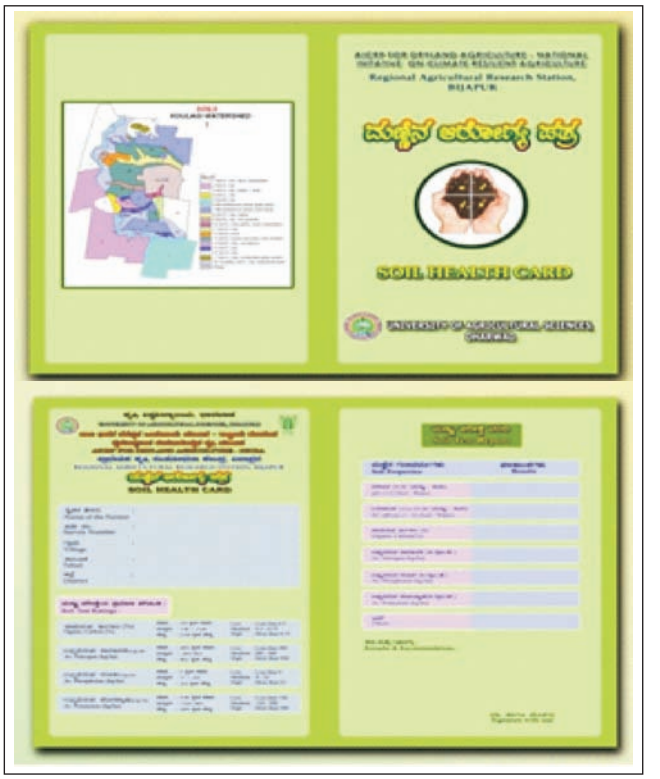

Fig. 154 : Soil Health Cards to each farmer in Kavalagi village, Bijapur centre

Fig. 155 : Activities of Community Seed bank developed in NICRA villages, Arjia centre

3.7. Publications

a) Research Papers published in Journals

Agrawal R.K., Satyapriya, Singh J.B., Ramesh Singh, Sunil Kumar, Sharma, P., Rai, S. K., Shyama Kumari and Deepty Shukla. 2012. Improvisation of Agri-Horticultural interventions based on Matrix Ranking. Journal of Agroforestry.

Jat, M.L., Sharma, S.K., Balyan, J.K., Sharma, R. K. and Jain, L.K. 2009. Drought Severity and Its Impact on Crop Production in Western India. Annals of Arid Zone. 48(2): 185-186.

Jat, M.L., Sodani, S.N., Sammauria, R., Sharma, S.K., Sharma, K. L., Mishra, P.K., Shankar, G.M., Kothari, A.K., Jain, L.K., Balyan, J.K. and Sharma, R.K.. 2011. Management of drought through crops and varietal diversification under dryland areas of Western India Indian Journal of Dryland Agricultural Research and Development., 26 (1): 32-40.

Satyapriya, Agarwal Rajiv Sharma Purushottam, Singh Maharaj, Rai, S.K, Upadhaya, JP and Singh, RP. 2012. PRA and its role in reorienting Agri- Horticultural interventions for Technology Demonstrations in a Participatory Action Research mode in Semi arid region. The Journal of Rural and Agricultural Research. 12(1): 94-97.

Satyapriya, Sharma, P. Singh, Maharaj, Agarwal, Rajiv and Singh, R.P. 2011.Gender Issues in indigenous technical knowledge. The Journal of Rural and Agricultural Research. 11(1); 83-87.

b) Books, Book Chapter - Reports

Agarwal, RK, Satyapriya, Singh, J.B., Kumar Sunil, Rai, S.K. and Sharma Purushottam.2011. A PRA Report of Kadesarakala. NICRA Project, IGFRI, Jhansi. pp:1-48.

Krashak dairy. 2011. Published by AICRPDA, College of Agriculture, Indore.

Ramachandrappa, B.K., Dhanapal, G.N., Indrakumar, N., Mariraju, H., Balakrishna Reddy, P.C., Jagdesh, B.N. "Dry land technologies for Alfisols of southern dry region of Karnataka and success stories"

Satyapriya and Agarwal R.K. April, 2012. Fodder Pocket Diary. Published by IGFRI, Jhansi

c) Popular articles

Anandhi, P. and Ramkumar, J., 2012. Crop protection techniques in rainfed pulses. In: Training manual on Technologies for yield improvement for dryland crops. P: 22-25.

Jawahar, D. " Kalanilai mattrathukku ugantha velanmai thodakka vizha" published in Dinamani paper dt. 1st September 2011.

Jawahar, D. "Velanmai thodakka vizha" published in Dinathanthi 1st September 2011.

Jawahar, D. 2012. Integrated Nutrient Management for dryland crops. In: Training manual on Technologies for yield improvement for dryland crops.

Ramkumar, J. and Anandhi, P., 2012. Cotton pests, management and control measures. In: Training manual on Technologies for yield improvement for dryland crops. P: 29- 32.

Renukadevi, A. and Jawahar, D., 2012. Soil management techniques to reduce global warming. In: Training manual on Technologies for yield improvement for dryland crops. P : 16-21.

d) Technical Calendars

Satyapriya, Agarwal, R.K., Singh Harshwardhan and Kumar Sunil. 2012. Round the year silvipasture and horticultural activities. Published by IGFRI.

Satyapriya, Agarwal, R.K., Singh Harshwardhan, Kumar Sunil, Singh, M., Upadhaya, J.P. and Dev, K. 2012. Round the year Agricultural activities. Published by IGFRI.

Satyapriya, Sharma, P, Kumar Sunil, Agarwal, R.K., Singh Harshwardhan and Dev, K. 2012. Round the year Animal Husbandries activities. Published by IGFRI.

e) Leaflet

Agarwal, R.K., Satyapriya, Kumar Sunil, Rai, S.K and Singh, H.V. April, 2012. Jowar. Published by IGFRI

Agarwal, R.K., Satyapriya, Kumar Sunil, Rai, S.K. and Singh, J.B. April, 2012. Berseem. Published by IGFRI.

Agarwal, R.K., Satyapriya, Singh Maharaj, Singh, J.B. and Kumar Sunil. April, 2012. Pearlmillet. Published by IGFRI.

Jawahar, D, Muppidathi, N., Rajeswari, M., Rangaraj, T., Renuka devi, A., Umamaheswari, C., Boomiraj, K., Sritharan, N., Ramkumar, J. and Marimuthu, M.. Prepared a leaflet highlighting the activities of NICRA scheme.

Satyapriya, Agarwal, R.K., Kumar Sunil and Pandey Sadhna. April, 2012. Oat. Published by IGFRI.

Satyapriya, Agarwal, R.K., Sharma, P. and Singh Harshwardhan. April,2012. Cowpea. Published by IGFRI.

Satyapriya, Agarwal, R.K., Singh, M., Kumar Sunil and Rai, S.K. April, 2012. Maize. Published by IGFRI.

Satyapriya, Agarwal, R.K., Kumar Sunil and Singh, M. April,2012.Guinea Grass and Hybrid Napier. Published by IGFRI.

Singh, K.A., Agrawal, R.K., Satyapriya, Singh, J.B., Rai, S.K. and Sunil Kumar. 2011. Jalvayu amutthanshil Krishi par Rashtriya Pahal (NICRA Project) - Hi. 2011. IGFRI, Jhansi.

3.8. Visitors to NICRA Adopted Villages

During the period, on-station and on-farm demonstrations were visited by dignitaries, scientists (SAUs, CRIDA) and officials of State and Central govts. etc.

Table 197 : Distinguished Visitors to NICRA adopted villages

Visits-Visitors to the NICRA villages	Date
Jagdalpur	
A.K. Jaishwal, Principal Scientist & Head, Dept. of TOT,	6-04-2011 to 7-04-2011
B.P. Katlam,Scientist, Entomology, IGKV, Raipur	
Sh. P.R. Sahu,CGM, NABARD, Raipur	09-07-2011
C.R. Prasanna, CEO, Zila panchayat, Jagdalpur, Bastar	13-09-2011
G.R.Maruti Shankar, I/c, Project Coordinator, AICRPDA	20-10-2011
S.K. Shrivastava, ADR, IGKV, Raipur	
A.K. Swarawagi, Principal Scientist, GPB, IGKV, Raipur	
S.K. Swarawagi, Principal Scientist (Agro) IGKV, Raipur	
Sh. Anbalgan P., IAS Collector, Bastar, Chhattisgarh	
Sh. G.K. Nirmam,JDA, Bastar Division, Govt. of Chhattisgarh	05-11-2011
Sh. N.L. Pandey,DDA, Jagdalpur	
S.N. Panda,Professor, IIT Kharagpur	26-02-2012
Arjia	
Sh. J.K. Tanwar, Joint Director (Agril.), GOR, Agril.	01-07-2011
G. Ravindra Chary, Principal Scientist, AICRPDA, Hyderabad	26-08-2011 to 27-08-2011
R. Nagarjuna Kumar, Scientist, AICRPDA, CRIDA,Hyderabad	
R.S. Dohare, Principal Scientist, Zonal Coordinator,Unit, Zone VI, Jodhpur	
R.S. Singh, Head, NBSS & LUP, Regional Centre, Udaipur (Rajasthan),	
P.L. Maliwal, Director Extension, MPUAT, Udaipur	
P.K. Gupta, Zonal Director Research ARS, Udaipur	
B. Rao,Prof. & Dean, Sardar Patel Agril. Univ., Merrut (UP)	12-10-2011
Sh. Y.P. Singh, V.S. Yadav,T&M Officer, APM, ITS Ltd. Lucknow	
A.K. Dhama,Hon'ble Vice Chancellor, SKRAU, Bikaner	17-10-2011
G.L. Keshava,Dean, SKN College of Agril. Jobner, Jaipur	

3.9. Linkages developed

The AICRPDA centres developed linkages with state line departments, KVKs, ATMA, ICAR Institutes, NGOs, State / Central Government schemes / programmes for implementation of NICRA programmes and capacity building of various stake holders (Table 198).

Table 198 : Linkages developed by AICRPDA centres

Center	Linkages developed
Anantapur	Department of Veterinary / Agriculture; Agricultural market yard and voluntary organizations like MYRADA;
Arjia	Directorate of Agriculture; State Govt., Jaipur; AICRP on Arid Legume; NBSS & LUP; AICRP on Agromet; Panchayat Raj Institutes; Dept. of Horticulture; Dept. of Animal Husbandry; ATMA; Watershed programs; KVK; District Rural Development Agency- District Water Management Agency; NGOs; NABARD; FES (NGO); BAIF (NGO)
Bijapur	Department of Agriculture, Bijapur; Department of Horticulture, Bijapur; Department of forestry, Bijapur; NGO (AYERI watershed project);
Indore	Dept. of Horticulture; Animal Husbandry, ATMA; Watershed programs; KVK, NGOs, NABARD
Jhansi	State Agricultural Department; Indian Agricultural Research Institute, RRS Indore, M.P.; C S Azad University of Agriculture and Technology, Kanpur, U.P;
Rajkot	Joint Director of Agriculture, Old Collector Compound, Rajkot; District Watershed Development officer, Lal Bunglow, Jamnagar; District Forest officer, (Social Forestry), Jamnagar; Deputy Director of Horticulture, Old Collector Compound, Rajkot; Deputy Director of Animal Husbandry, Pedok, Rajkot; District Development Manager, (NABARD) Jamnagar; President Village Watershed Development Committee, Pata Meghpar Tehsil : Kalawad, Vasundhra Trust NGO, Rajkot; ATMA, Jamnagar; WASMO, Jamnagar
Rakh Dhiansar	Division of Agronomy, Agricultural Engineering, Soil Science and Agricultural Chemistry, Integrated Agromet Agro advisory Services (AMFU), PBG, Pulses Research Sub-Station, Samba, Agriculture, J & K State Govt.; Department of Horticulture, J & K State Govt.
SK Nagar	State Agricultural Universities; Gujarat Land Development Corporation (GLDC), Gandhinagar, Gujarat; Water and Land Management Institute (WALMI), Anand, Gujarat; Department of Agriculture, Animal husbandry, Horticulture, Rural Development, Central Soil Salinity Research Institute (CSSRI), Karnal, Haryana; Central Arid Zone Research Institute (CAZRI), Jodhpur, Rajasthan; Gujarat Water Resource Development Corporation, Gandhinagar, Gujarat;
Varanasi	KVK, Varanasi; KVK, Mirzapur; KVK, Sant Ravidas Nagar; KVK, Chandauli; KVK, Sonbhadra;

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Maize based production system			
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Acronyms

AAU ..... Assam Agricultural University
ADG ..... Assistant Director General
AICRPAM ..... All India Coordinated Research Project on Agrometeorology
AICRPDA. ..... All India Coordinated Research Project for Dryland Agriculture
ANGRAU ..... Acharya NG Ranga Agricultural University
ARS ..... Agricultural Research Station
ATMA ..... Agricultural Technology Management Agency
BC ratio. ..... Benefit cost ratio
BHU ..... Banaras Hindu University
CAZRI.. ..... Central Arid Zone Research Institute
CCSHAU. ..... Chaudhury Charan Singh Haryana Agricultural University
CHC ..... Custom Hiring Centre
CHMC. ..... Custom Hiring Management Committee
CRIDA ..... Central Research Institute for Dryland Agriculture
DARE . ..... Department of Agriculture Research and Education
DAS ..... Days after Sowing
DDA ..... Deputy Director of Agriculture
DDG ..... Deputy Director General
DG ..... Director General
DHA ..... Dehydrogenate Activity
FAD ..... Focused Group Discussion
GEY ..... Grain equivalent yield
HW ..... Hand weeding
ICAR ..... Indian Council of Agricultural Research
IGFRI. ..... Indian Grassland and Fodder Research Institute
IGKV ..... Indira Gandhi Krishi Vidyapeeth
IIT ..... Indian Institute of Technology
IMD ..... Indian Meteorological l Deportment
JAU ..... Junagadh Agricultural University
JDA ..... Joint Director of Agriculture
JNKV ..... Jawaharlal Nehru Krishi Vishwa Vidyalaya Peeth
MAU ..... Marathwada Agricultural University
MEY ..... Maize Equivalent Yield
MJ ..... Mega Joules
MM ..... Millimeter
MPKV ..... Mahatma Phule Krishi Vidyapeet
MPUA&T ..... Maha Rana Pratap University of Agriculture & Technology
MYRDA . ..... Mysore Resettlement and Development Agency
NABARD ..... National Bank for Agriculture and Rural Development
NBSS & LUP .. National Bureau of Soil Survey and Land Use Planning
NDUAT ..... Narendra Dev University of Agriculture & Technology
NGO ..... Non Government Organization
NICRA ..... National Intiative on Climate Resilent Agriculture
NRM ..... National Resource Management
ORP ..... Operational Research Project
OUAT--- ..... Orissa University of Agriculture & Technology
PAU ..... Punjab Agricultural University
PC Unit ..... Project Coordination Unit
PDKV ..... Dr. Panjabrao Krishi Vidypeeth
RA ..... Research Associate
RDF ..... Recommended dose of Fertilizer
REY ..... Rice Equivalent yield
RRS ..... Regional Research Station
RWUE ..... Rain Water Use Efficiency
SAU ..... State Agricultural University
SEY ..... Soybean Equivalent Yield
SKDAU ..... Sardar Krushinagar Dantiwada Agricultural University
SKNagar ..... Sardarkrushi Nagar
SKRAU . ..... Swami Keshwananda Rajasthan Agricultural University
SKUAS&TJ.... Sher-e-Kashmir University of Agricultural Science & Technology
SMBC ..... Soil Microbial Carbon
SMW ..... Standard Meteorological Week
SRF ..... Senior Research Fellow
TNAU ..... Tamil Nadu Agricultural University
TOT ..... Transfer of Technology
UAS _B ..... University of Agricultural Sciences, Bangalore
UASD ..... University of Agricultural Sciences, Dharwad
VCRMC ..... Village Climate Risk Management Committee
WASMO ..... Water and Sanitation Management Organization

शहर 6 दैनिक जागरण

परिवर्तन से निपटने तैयार की

तरुण भारत

कोरडवाहू तंत्रज्ञान कार्यश

கோவில்பட்டி வேளாண் ஆராய்ச்சி நிலையம்

வேளாண்மை திட்ட தொடக்க

भारतीय कुटुंब शेती पद्धतच फायदेशीर

दैनिक भास्कर

रीवा की धरती बना खेती की प्रयोगशाल

देश के 19 कृषि महाविद्यालयों में हो रहा अनुसंधान

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अमीनाबाद

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दिव्य भास्कर

10 अहमदाबाद, शुक्रवार 21 ओक्टोबर 2011

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